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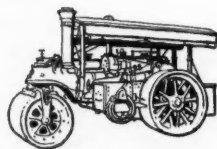
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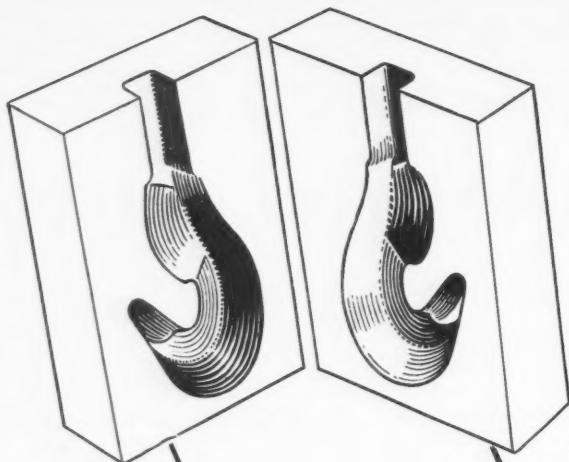
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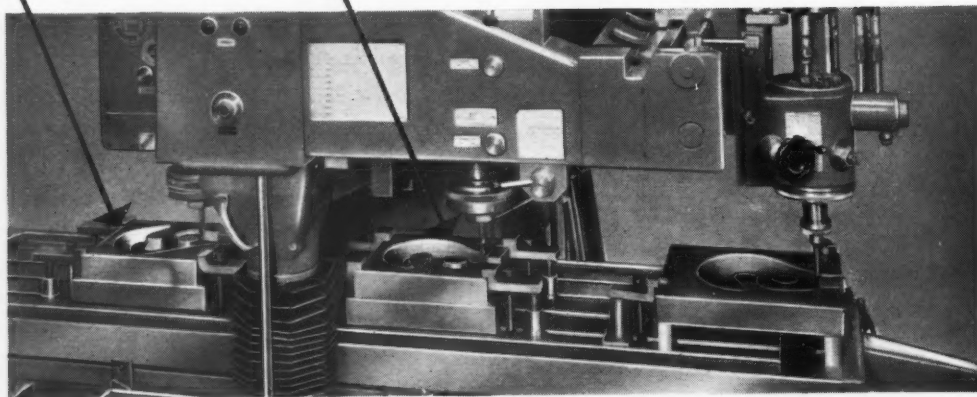
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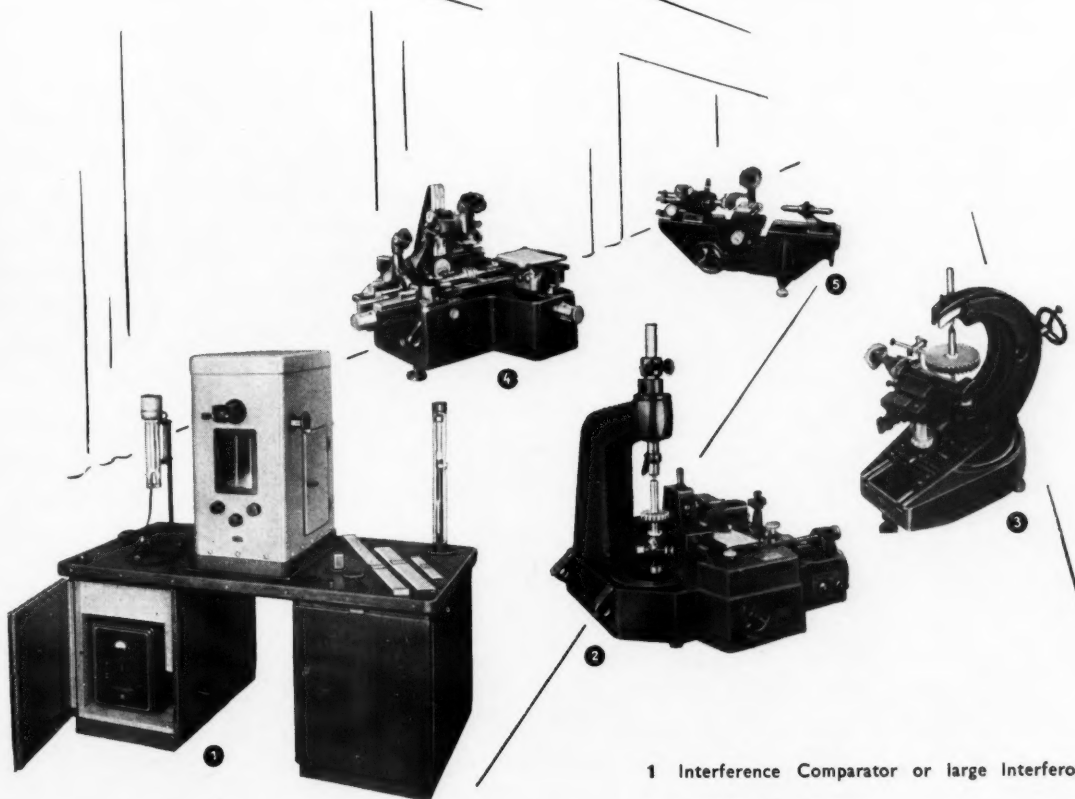
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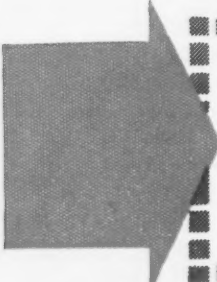


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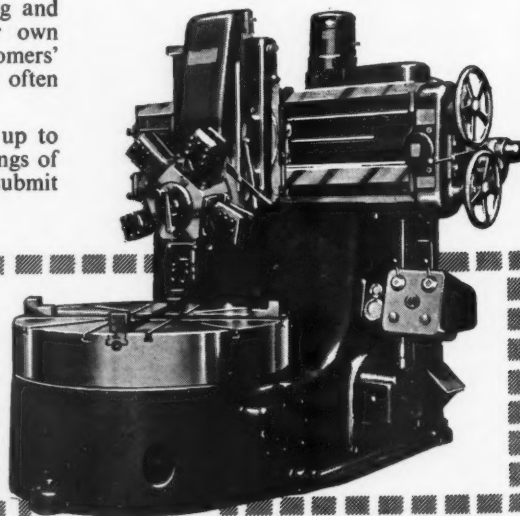
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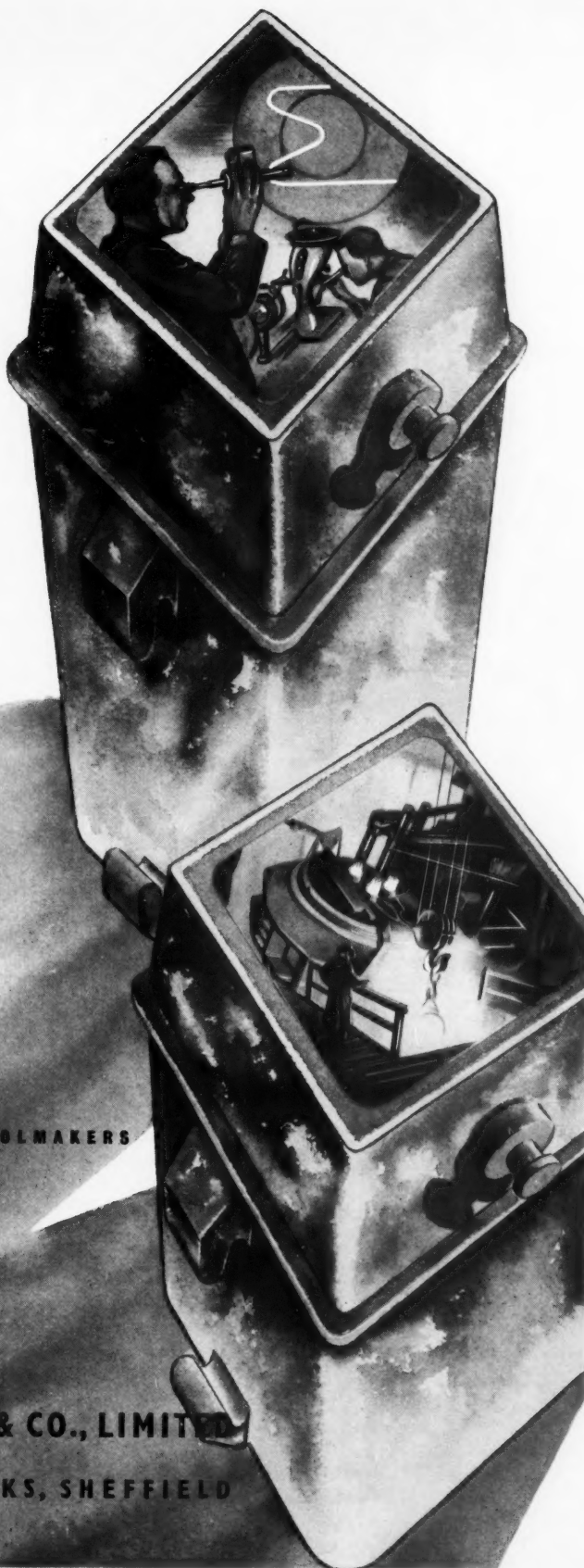
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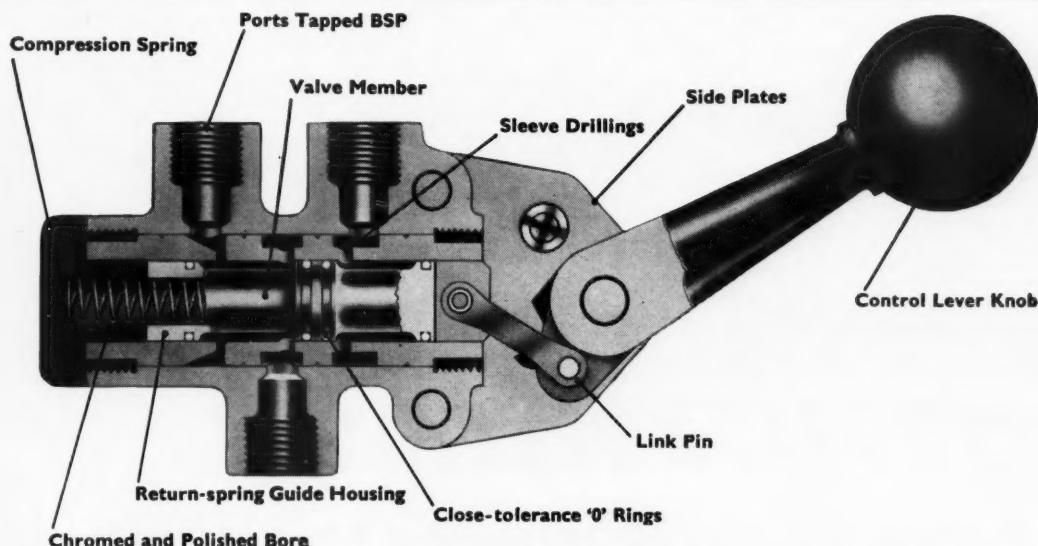
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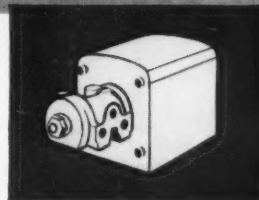
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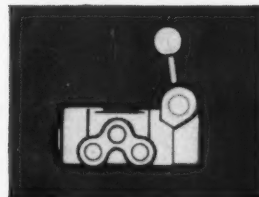
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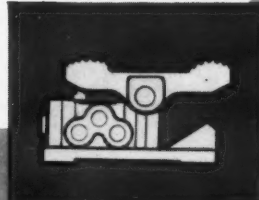
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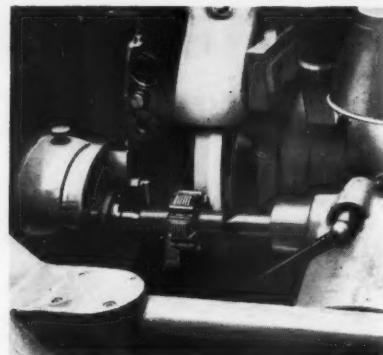


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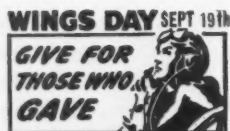


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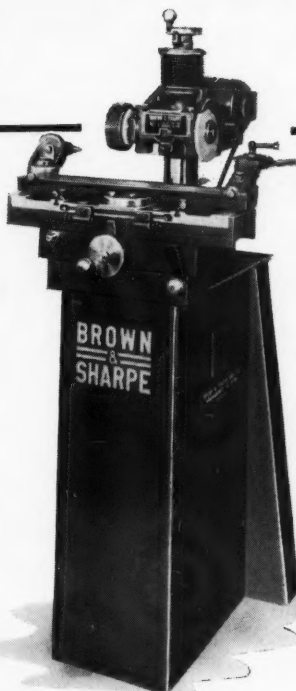
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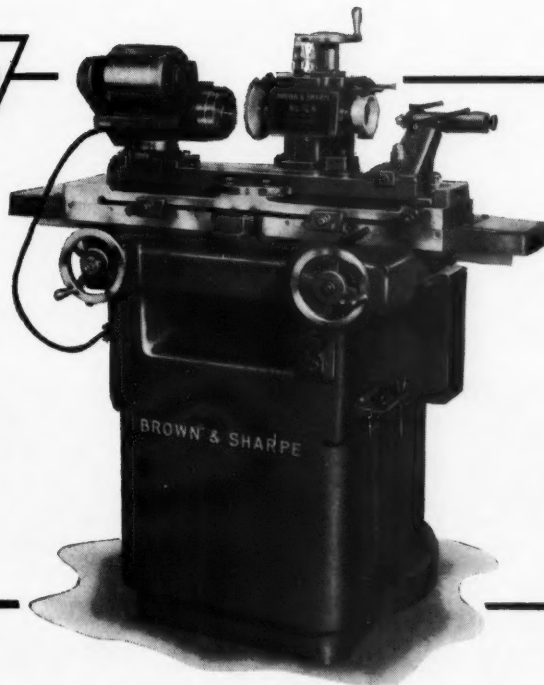
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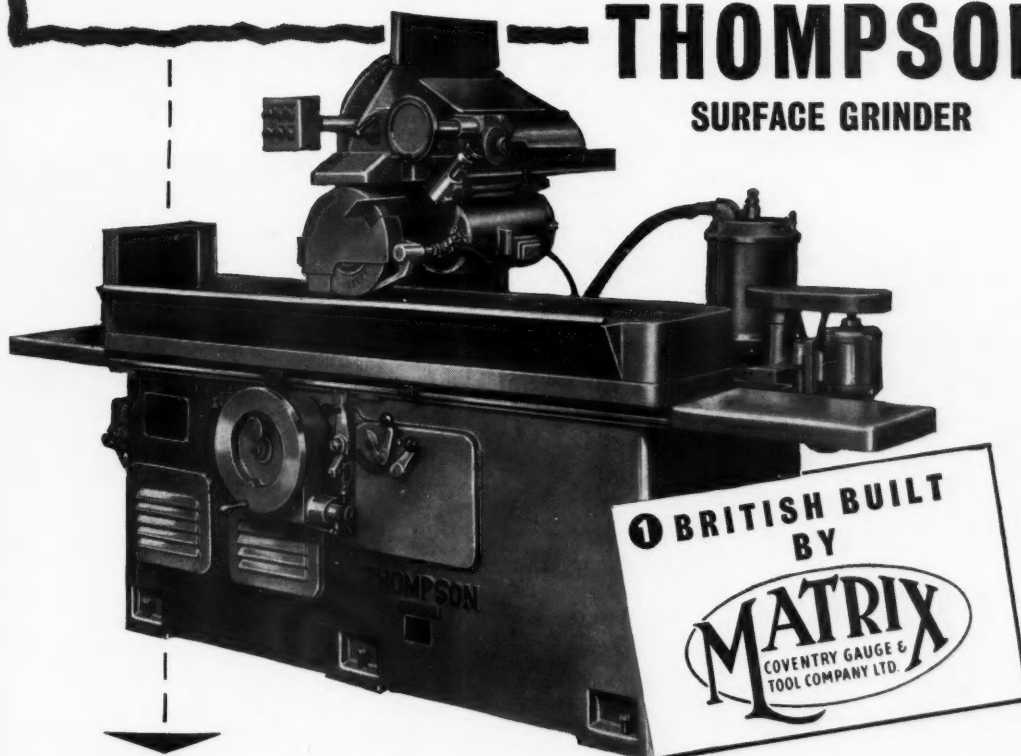
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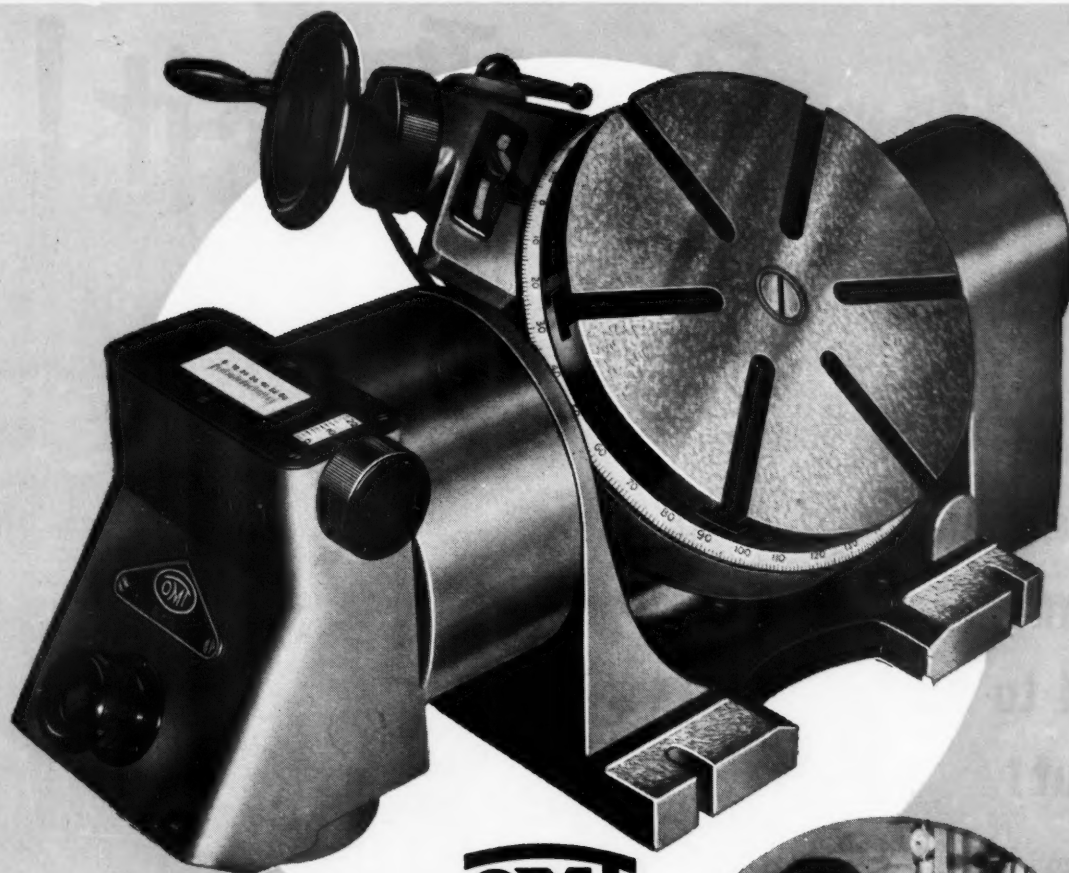
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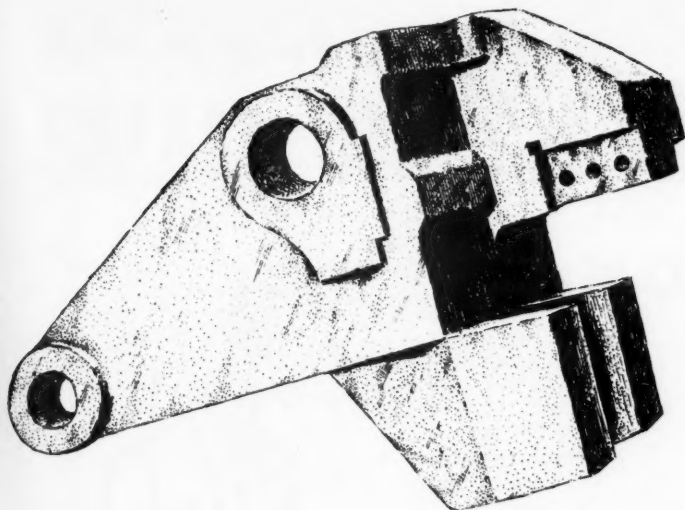
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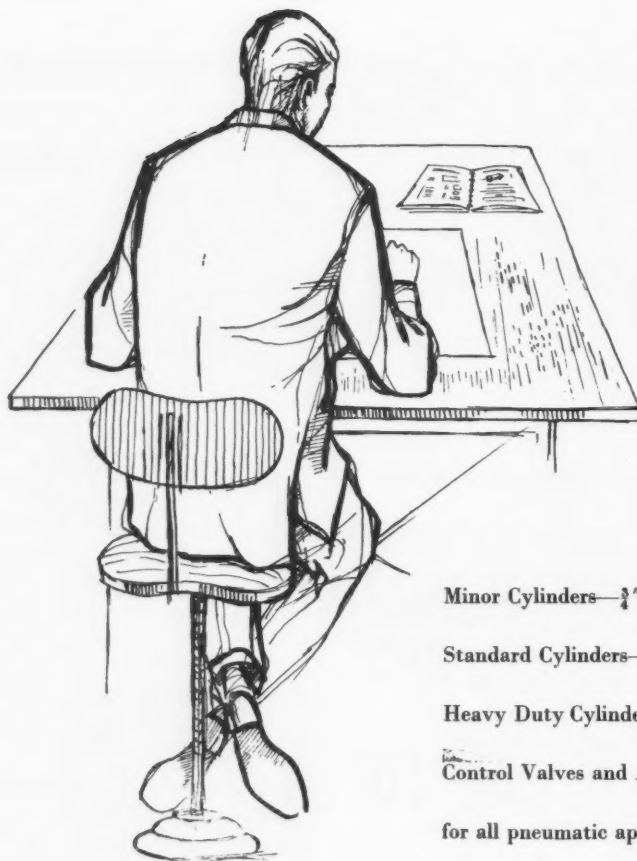
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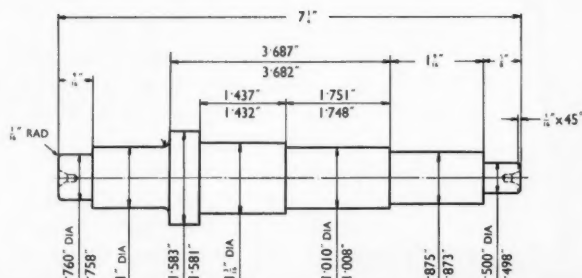
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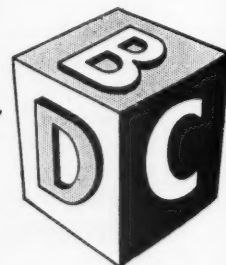
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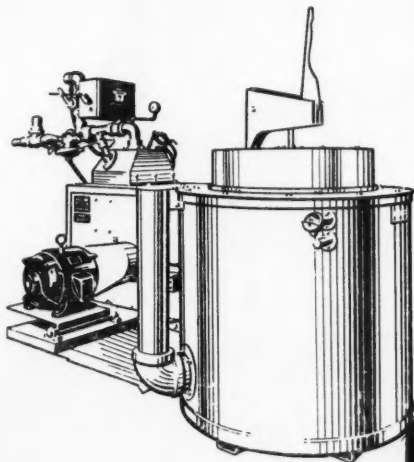
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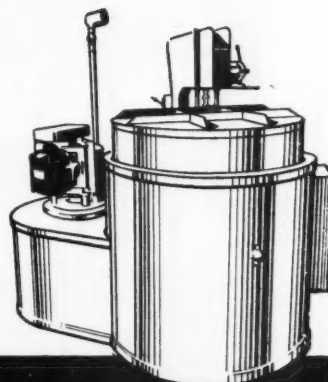
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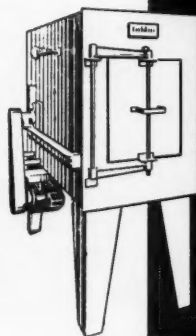


(right) Batch type super Cyclone Furnace

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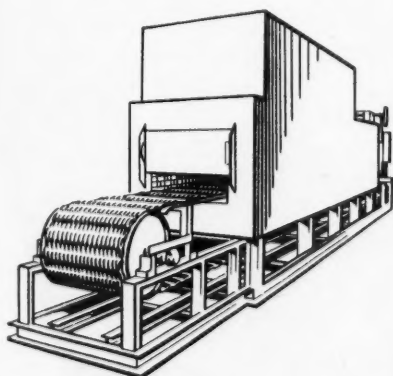
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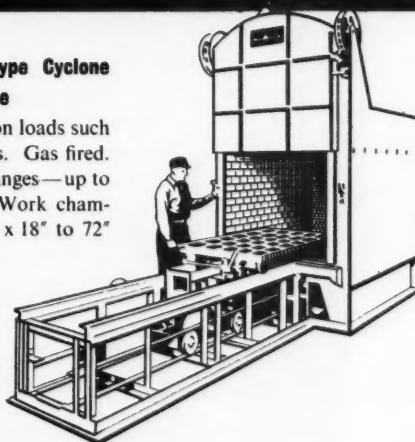


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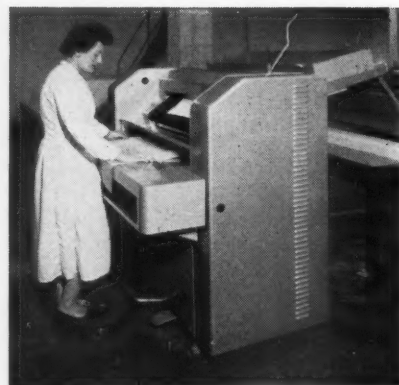
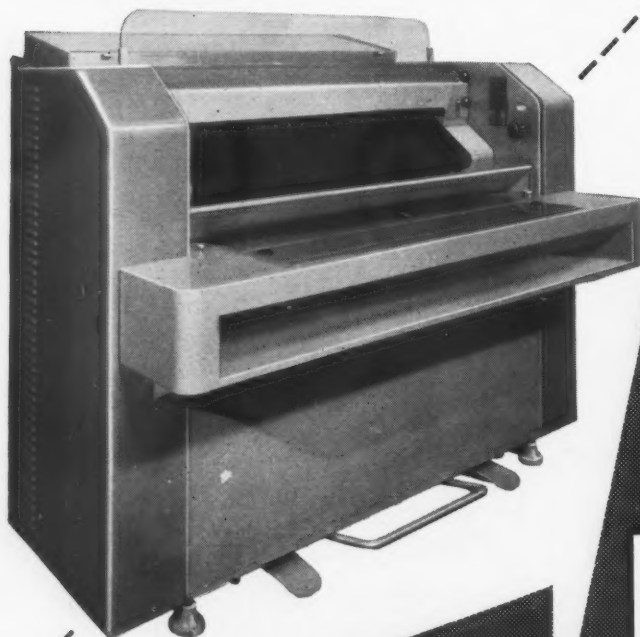
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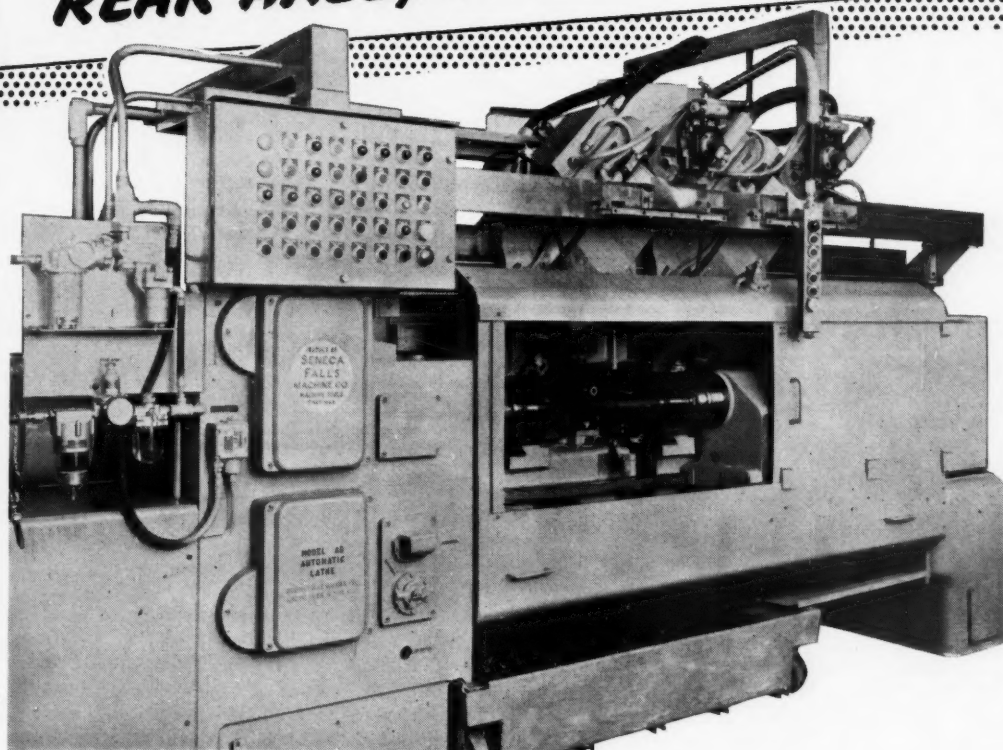


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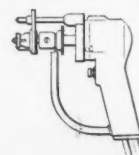
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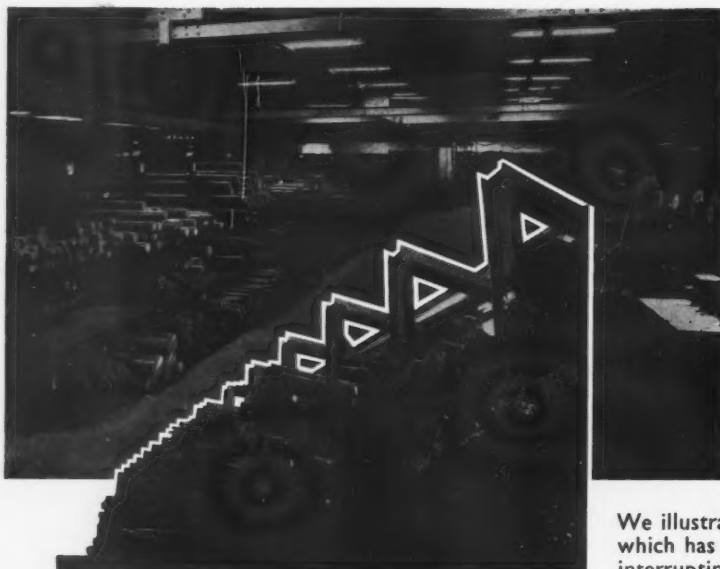
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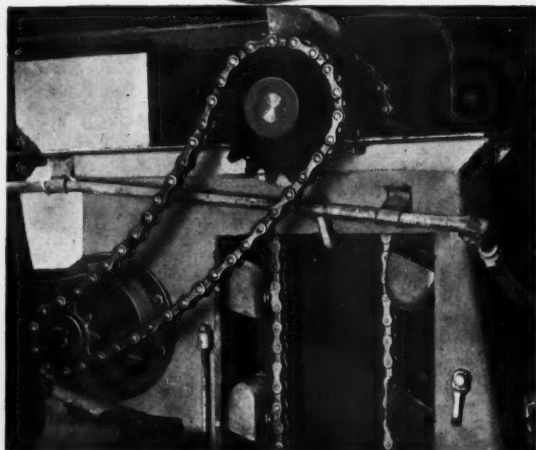
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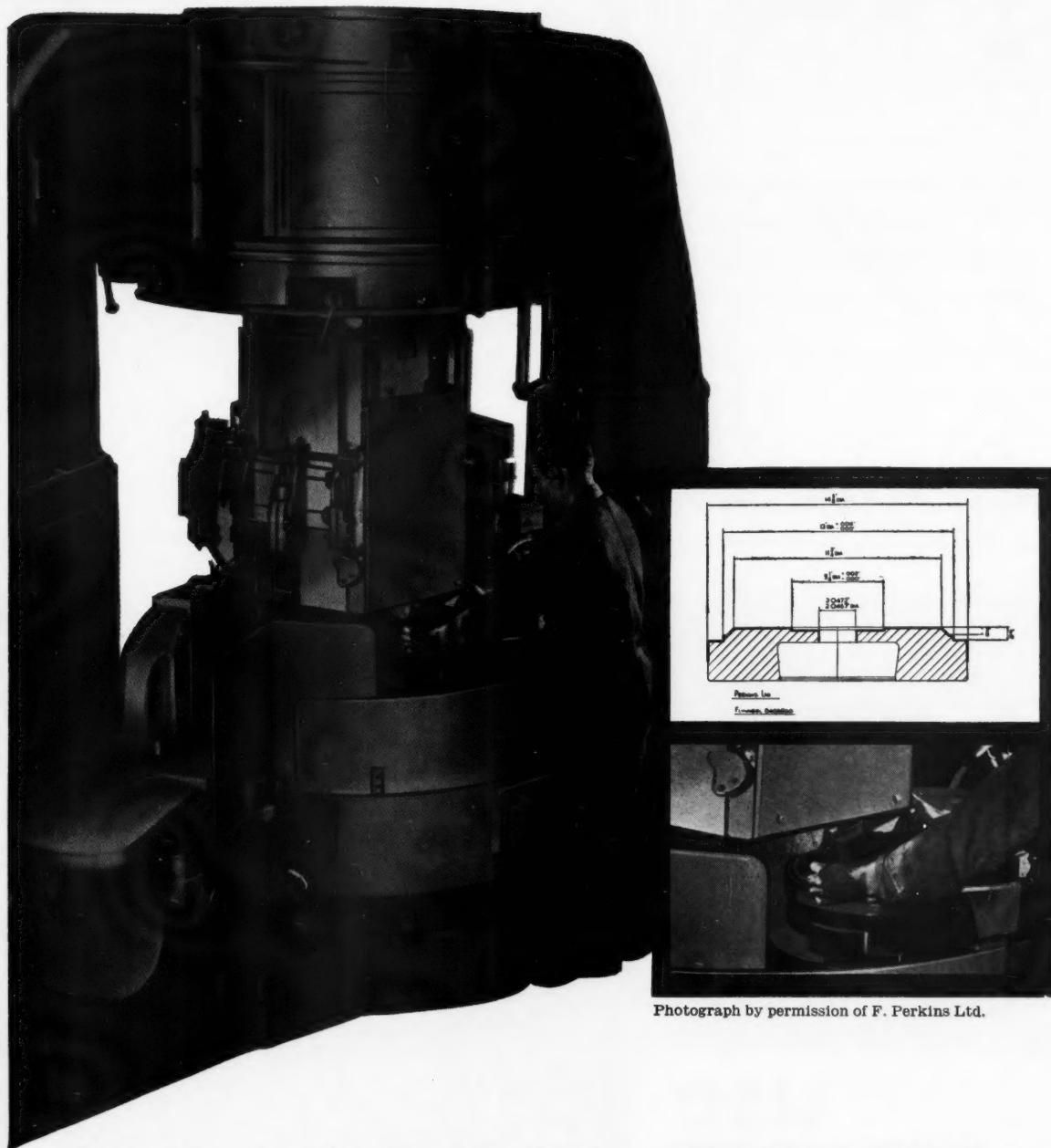
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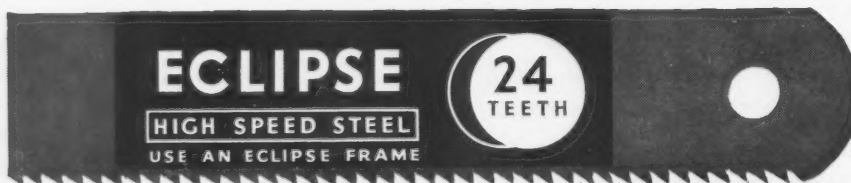
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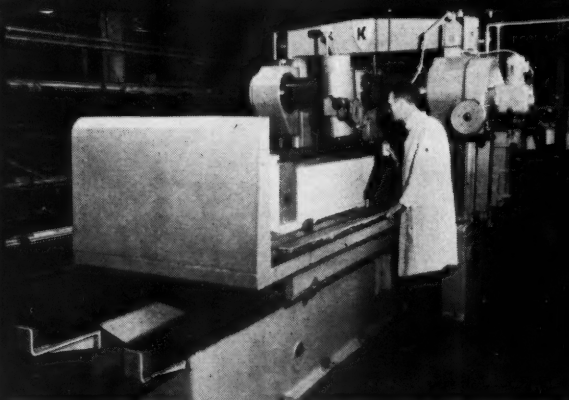
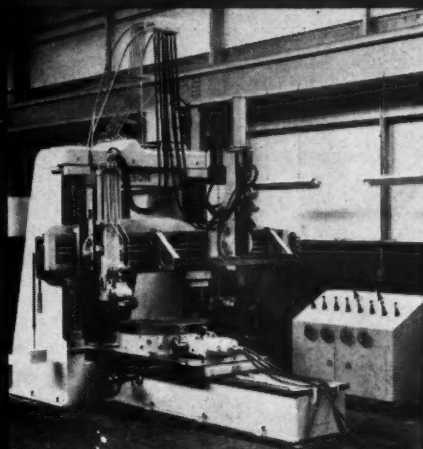
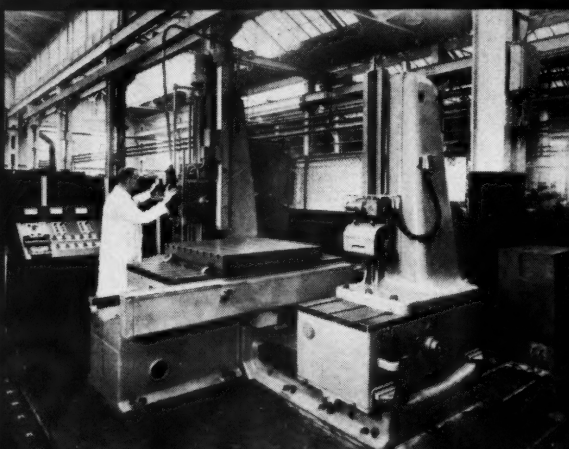
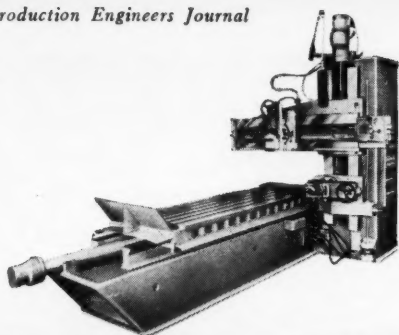


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PRODUCTION TECHNOLOGY AT THE UNIVERSITY OF MANCHESTER

*A Report prepared for the Journal
by Dr. F. KOENIGSBERGER, M.I.Mech.E., M.I.Prod.E.,
Reader in Machine Tools and Production Processes,
Faculty of Technology, University of Manchester.*

THE problems generally associated with the subject of production embrace aspects of technology, the mechanics of metal forming and cutting, the technology of joining processes, etc., on the one hand, and of administration and management (investment and sales policies, labour relations, time and motion study, etc.) on the other. The aim of all these varying aspects is to create the means for manufacturing products which are both functionally efficient and economically competitive.

The fact that the word "cost" must be written with capital letters in production investigations, even those concerning purely technical aspects, makes production technology a subject which is sometimes frowned upon by engineering scientists. However, if the technological problems of production are not approached in the same manner as other technological subjects, production technology is bound to fail in its purpose, because competitive progress by means of purely empirical developments alone is impossible.

In engineering design and research, success lies in the ability to combine theoretical necessities and practical possibilities. Production, by virtue of its definition, means the practical creation of goods, and optimum results cannot be obtained, therefore, unless not only practical possibilities, but also necessities, are considered and analysed. This means that even in the teaching of such a subject, it is impossible to divorce considerations of practical aspects from those of theoretical analysis and creative synthesis. Moreover, in an examination, it is often difficult to ask precise questions and almost impossible to expect exact answers.

More than in many other fields, the value of teaching can be much enhanced by combining it with demonstrations of actual researches in production problems. A combination of teaching and research appears, therefore, to be the best way in which a University can include production technology in its programme.

Before anyone can try to study production problems in engineering, he must be first and foremost an engineer, and students wishing to specialise in this field must have a sound basic engineering knowledge. It would be unthinkable for a man to become a heart specialist without having first qualified as a doctor.

a production option

In the Faculty of Technology, University of Manchester, a production option is offered to students of mechanical engineering in their final year. The syllabus differs from that of the general mechanical engineering course in that courses on machine design, mechanics of fluids and applied thermo-dynamics are omitted, the treatment of others such as mathematics is reduced, whilst the treatment of management principles is amplified, and courses on metrology, mathematical statistics and quality control, theory of metal processing, production control, selection and efficiency of labour, etc., are introduced. Instead of design exercises, the students are given a production project in which they have to consider the production in given quantities (sometimes small batch production, sometimes large quantity production and sometimes flow production) of simple assemblages, such as the crankcase assembly of a motor-cycle engine, a gearbox or a tail stock for a centre lathe, etc. They have to judge the design features and possibly modify the detail design to suit their proposed manufacturing procedure; to plan the machining operations, select suitable machine tools and design special tools, jigs and fixtures; to determine the approximate times of manufacture and the loading of the various machine tools; and finally, to lay out a workshop suitable for the manufacture of the assemblage in question.

Undergraduates are also introduced to some items of special interest in the post-graduate research programme. This connection between teaching and research is considered highly important. The following short description of the research work which has been carried out or which is at present in progress may show the principles of planning the research programme.

During the last eight years, the influence of production processes on design considerations has been investigated and reports on design stresses, stress distribution and fatigue of fillet welded connections, the load-carrying capacity of welded structural elements and the influence of finishes obtained by machining and flame cutting on fatigue strength, appeared in the publications of The Institution of Mechanical Engineers, and The Institute of Welding.

fundamentals of cutting processes

Earlier investigations into the fundamentals of cutting processes were carried out at the Manchester College of Technology in 1903 by Nicholson, who was in fact one of the first to succeed in measuring the forces acting at the cutting edge of a tool, thus laying a foundation stone of machine tool technology as a science. Unfortunately, it was only possible to take up again such work during the last 15 years or so, but now work is proceeding on cutting conditions with carbide tools, problems concerning the formation of the built-up nose, etc., and a number of Papers have already been published.

Work is also carried out on an investigation into milling operations, and a study of the performance of specially designed dynamometers was reported in the Journal of The Institution of Production Engineers in December, 1958. A development project for the investigation of the design of elements for machine tools suitable for automatic electronic control is at present in progress, and a preliminary report on this work was given in a Paper to the 1958 Production Conference and published in the Journal of The Institution of Production Engineers, October, 1958.

It is appreciated that metal cutting and welding processes have been given prominence in the research work carried out in recent years, but plans are at present in hand for the development of research work covering forming and other processes. A research study of the spark erosion process has also been recently completed.

(concluded on page 437)

THE INDUSTRIAL ENGINEERING REVOLUTION



by SAMUEL EILON, Ph.D., M.I.Prod.E.

*Associate Professor in Industrial Engineering,
Israel Institute of Technology.*

Summary

Classical industrial engineering was based on five main foundations: the rule of intuition, the philosophy of the one best way, the deterministic system, the principle of simplification and the classical methods of experimentation. Intuition rarely yields satisfactory results in complicated systems and is giving way to operational research techniques. The philosophy of the one best way has been replaced by the philosophy of the better way, and the deterministic methods by statistical analysis.

We are increasingly aware of the inadequacy of the principle of simplification and believe that industrial operations are inherently complex and require a new approach to their study. The Hawthorne experiments demonstrated the effect of observation on the observed system and also emphasised the necessity of devising new methods for industrial engineering research and study of administrative behaviour.

INDUSTRIAL engineering is a comparatively young subject, which grew with the rapid industrial development of Western Europe and America, until in recent years it began to occupy an honourable position in institutions of higher learning. The pioneers in this field endeavoured, at the beginning of the century, to establish it on scientific foundations, to formulate "laws" which would describe and explain phenomena and relations between cause and effect, and to outline principles for procedure and organisation in order to achieve a desirable level of performance. But, with all its "scientific" principles, industrial engineering remained more an art than a science. The success of experts in the field can perhaps be attributed more to a sixth sense based on accumulated experience than to the application of set laws and principles, which are supposed to lead the engineer step by step to the desirable solution.

Like many other subjects, industrial engineering has experienced in the past two decades a rapid development, which led to a drastic change in views and outlook. The classical industrial engineering can be said to have been established on the following five foundations:

- the rule of intuition;
- the philosophy of the one best way;
- the deterministic system;
- the principle of simplification; and
- the classic methods of experimentation in physics.

I shall try to review in this Paper the changes in our understanding of these basic concepts and the way they affect our whole approach to and evaluation of industrial engineering problems. We are now

experiencing literally a revolution in this field of engineering, a revolution that will transform it into a completely new engineering science.

the rule of intuition

When an industrial engineer or a manager is supplied with specific data, on the basis of which he has to take a decision or to outline an engineering plan, what is the conventional method that guides him in his quest for a solution? He tries to digest the facts in his mind, he outlines several logical alternatives for a solution and proceeds to compare them in order to select the best. In this process of comparison, he tries to visualise the possible results that can be expected of each alternative and in this he is guided by his past experience, or by the experience of others, and he mainly uses his sense of intuition to assess these results qualitatively or quantitatively and to relate results of one method or system to those of another.

What is intuition? Intuition is a process of thinking, which is difficult to dissect into individual factors or sequences. It is quite often based on the principle of identification of given data of a specific problem with previous experience, and is normally associated with rapid transfer from one sequence to another. This process, however, may be too closely attached to identification with past associations, rather than with the problem at hand. Thus, not all the relevant factors may play a relevant role in the procedure of arriving at a solution, and while intuition sometimes leads to the right answer for the wrong reasons, it should be remembered that an intuitive approach quite often results in a wrong solution, or in a solution which is not the best one. Those instances where the intuitive approach yields wrong answers are usually revealed when undesirable results are obtained. But in most cases, when the suggested solution is neither catastrophic nor the best one, we tend to regard the intuitive solution as a successful one, and if somebody suggests a better solution we usually say that "it is very easy to be clever in retrospect" or that "the conditions have changed in the meantime and we now have information which we did not have before". It is true that sometimes changes in the nature of the problem do occur, but the significance of these changes, both qualitatively and quantitatively, is important in the evaluation of the solution. In many cases we can formulate in advance the nature of the changes that may arise, some of them even quantitatively, but the percentage of the cases in which the intuitive method provides a solution that takes such details into account, is almost negligible.

How does intuition work and what is the relation between intuition and previous experience? To what extent are intuitive processes in the mind related to past associations and to what extent are they independent of the external world, forming so to speak an isolated system in which the computation yields absolute values? These are complicated problems which provide rich material for research on the structure and performance of the mind and it is not

intended to enlarge on them here. But for the purpose of our discussion it is possible to say that every thinking process consists of several elements or steps, each one leading forward in the quest of a solution.

The word "forward" is important here, since if the steps do not take us nearer to the target, it is necessary to have more steps from the starting point to get there, and the number of steps is significant in the actual attainment of the goal. Each element is fed with data from the previous element, then an operation based on the data takes place and the output is fed into the next element. Even if we assume that the computational operation itself at each element is free of errors, it is still doubtful whether the input to each element is always identical with the output of the previous one, because each input is accompanied by a suitable re-arrangement of the material and perhaps formulation of the facts in a form easily digestible by the computational operation. Putting the data in a new light or expressing it in different terms may lead to non-identification of input with preceding output. This is a second source of possible errors in the intuitive process, and the accumulated error increases with the number of elements. This is somewhat similar to several toy bricks put on top of each other. If the bricks are accurately located, the structure will be absolutely vertical. A small displacement of one brick in the structure causes a displacement of the top brick, while several displacements of several bricks may lead to an increased displacement of the top from its desirable location.

the short cut

Another aspect of the intuitive thought is the short cut, i.e., the elimination or combination of several elementary steps in the thinking process, based on an analogy of these elements with other known elements from past experience. This aspect is one of the amazing phenomena associated with the performance of the mind, but from the point of view of error making it has the same pitfalls of unidentical situations and distorted data.

The process of analytical thinking is not always as simple as described above. Usually the process is divided into several sub-processes, which have to be carried out simultaneously, which are interconnected and which influence each other. The input to a certain element may not be uni-directional; that is, it may not be obtained from one previous element but from several elements belonging to different processes, and similarly the output may be multi-directional to several elements. Here we have two important aspects: first, the capacity of the mind to carry out assimilation of several inputs to one element without distorting their accuracy and contents; and, secondly, the amount of complexity of simultaneous processes and multi-directional inputs and outputs that the intuitive mind can carry out, without unwarrantably eliminating complete processes in order to achieve simplicity. Both aspects can become sources of appreciable errors.

The intuitive processes have been mentioned at some length in order to point out the reasons for either their missing the target altogether, or for incurring accumulated errors of such a magnitude as to render the proposed solution unsatisfactory. The very fact that different intuitive minds give different solutions to the same problem, and that the solutions are usually not equivalent (i.e., it is possible to say that one solution should be preferred to another) would indicate the necessity of analysing methods that would yield a solution independent of intuitive faculties, and would therefore be free from the mistakes which might be attributed to them.

New methods in analysis of situations and systems are provided by operational research techniques, which facilitate the study of intricate and complex systems when any intuitive attempt to a solution is doomed to failure for two reasons: first, many systems of this kind have specific characteristics and it is difficult or impossible to draw conclusions about their nature from previous experience of other systems; secondly, the complexity of the systems and the large number of variables on which they depend, make it impossible for the human mind to achieve an effective absorption of all the facts and the intricate relationship between them. The tools of operational research can be used for a systematic analysis and quantitative evaluation of the characteristics of the system, and though intuition can always be of some help, just as it is helpful in the solution of mathematical problems, the autocratic rule of intuition in the solution of classical industrial engineering problems is coming to an end.

The first critical steps in the evaluation of industrial operations are the definition of the problem, the definition of the objective and the definition of criteria for measurement. It is often said that the definition of the problem is half-way to its solution, and this is probably quite true, as the definition of the problem inevitably entails gathering of adequate and relevant information and precise understanding of the characteristics of the factors involved. The definitions of the objective and the criteria for

measurement have undoubtedly been one of the major stumbling blocks of critical operational analysis in the past. Not only has there been a lack of agreement as to what objective is desirable; many managements have been trying to achieve several objectives at the same time, and quite often these objectives are not compatible with each other. It has often been asserted that the definition of objective is a matter for higher management and the task of the industrial engineer begins after that. In view of the confusion on this score in the past, and the different and sometimes conflicting criteria which have been applied in the study of operations, it would seem that a meticulous study of industrial objectives and criteria is warranted, if operational research methods are to be fully exploited.

the philosophy of the one best way

At the beginning of the century the pioneers in industrial engineering had already recognised the fact that there are large variations between different workers, between their methods of work and between their outputs. Frederick Taylor came to the conclusion that it is necessary to outline scientific methods in order to enable objective measurements with the aid of a clearly defined criterion. He asserted that the desirable maximum efficiency would be achieved if tasks in industry were undertaken by people trained for them. He wanted to solve the problem of existing variations by carefully selecting personnel, suitable in skill and aptitude for each particular job, and he called these people "first class men", a definition that aroused severe criticism at the time. Frank Gilbreth put the emphasis on the work method. He said that for the attainment of maximum efficiency there exists one method for the execution of each job which is "the best way", the acquisition of which should be the objective of operators' training. Gilbreth was prepared to admit that the existing variations between operators may cause deviations from the best method, even after the operators have been trained to use it, and he was prepared to allow

Dr. Eilon is a graduate of the Israel Institute of Technology, Haifa, where he was awarded the degrees of B.Sc.(Eng.) and Dipl.Eng.

He served his apprenticeship with the Palestine Electric Co. Ltd., and on the outbreak of hostilities in Israel in 1948, he was commissioned to the Israeli Defence Forces, where he acted in various capacities for two years, then served for three years with the rank of Major as Commanding Officer of the Israeli equivalent of a R.E.M.E. base depot.

In 1952, Dr. Eilon came to Imperial College for post-graduate studies, was appointed a Research Engineer at the College, and was awarded the D.I.C., and later the Ph.D. of the University of London. In 1955, he became a lecturer at Imperial College in charge of the Post-Graduate Course in Production Engineering. For the past two years he has been an Associate Professor in Industrial Engineering, in charge of the Post-Graduate Course in Industrial and Management Engineering, at the Israel Institute of Technology; has been Joint Chairman of the Centre for Advanced Management (forerunner of the Israel Management Association); a member of the Board of Directors of the Israel Institute of Productivity; and a member of the Council for Engineering and Architecture.

such deviations, provided the output attained by the best method was not affected. This philosophy of Gilbreth was enlarged upon by Alford, who said that this view was identical with the philosophy of the engineering standard. The one best way should be regarded as a relative engineering concept, which describes the best method that can be found under the given circumstances. "It is not an ultimate best way but is in the line of progress, and may be changed or modified as soon as a better way is discovered. The new way then becomes the best way until it is superseded by something better. To the one who accepts and applies this philosophy comes the grace and rhythm and perfection of motion of him who knows, and knows that he knows, and does what he knows, no matter what his work may be." ¹

This is quite a liberal interpretation of the philosophy of the one best way, but at the beginning of the century this philosophy was rigid, deterministic and static. Rigid, in that it implied that there exists only one method which is the best. Deterministic, in that it said that the method can be defined after suitable study and research. Static, in that it made the work system dependent on fixed parameters. But we are now beginning to understand that the three assumptions of this philosophy are unfounded. First, we are no longer confident that to every problem there is only one best solution, even when we overcome the obstacle of defining the criterion by means of which the solution should be evaluated. Many problems have several equivalent solutions and in the design of machinery and equipment, for instance, this phenomenon is well known. Secondly, we are now convinced that the deterministic outlook has no foundation either in theory or in practice. Theoretically, as we shall see later, we cannot be sure that the proposed method will really prove to be up to the mark, as hoped in advance, since the feeding of the method into the system may lead to some unexpected results. From the practical point of view, the classical assertion is that it is possible to find the method "after suitable study and research", i.e., the search is a function of time and money, and these are not always available in abundance. And, lastly, no work system is static. It cannot be defined in static terms but by statistical parameters. It changes with time and with the many variables on which it depends. Its characteristics change fundamentally with changes of methods, with changes of processes or even with changes of views.

Perhaps it is permissible to say that for the philosophy of the one best way has now been substituted the philosophy of the better way. The philosophy of the best way recognises one absolute idealistic method, a super target to be aimed at by every worker or engineer seeking perfection. The philosophy of the better way is the philosophy of reality. It asserts that every process of development is unlimited. In this process we are moving along an indefinite spiral which continuously transfers us into a new space and with each step the system is faced with new problems demanding their solution. In the search for a better method with limited facilities, it is of course possible to find several solutions, some of which will be better

than others, and this is where the real test of the engineer lies. The average engineer, without imagination and initiative, will be satisfied with any better solution, with the pretext that there is no need to make any special effort because we are not after a final and absolute method. A good engineer will try to achieve the maximum with the facilities at his disposal, will not be deterred by the infinite process of development and will not be drawn into apathy, but will regard it as a constant challenge, a source of interest, vitality and action. And is this phenomenon not typical of what happens in other fields of human endeavour?

determinism and probability

The first steps of industrial engineering were naturally based on the deterministic outlook and this view, to a certain extent, formed the background to the philosophy of the one best way. The deterministic approach was coupled with the belief that if a set of defined operations is followed, a certain result is obtained, and this same result can be expected to recur again and again from the same set. This view is reminiscent of a set of experiments in classical physics shown by a teacher to his students. He takes, for instance, a metal sphere, slightly smaller in diameter than the internal diameter of a ring at room temperature. He warms the sphere over a Bunsen burner and tries to push the hot sphere through the ring, exhibiting in this way the phenomenon of metal expansion with temperature. Each time it is sufficiently warmed, the teacher expects the sphere not to pass through the ring and he would be extremely surprised, and perhaps worried, if after proceeding with identical sets of operations the sphere would sometimes pass through the ring and sometimes not, and he would undoubtedly express the view that something had gone wrong in the structure or nature of the experimental apparatus.

In fabrication processes it has been well known for some time that the result is not deterministic in this sense, i.e., that after a recurring set of operations, a large variation in results is obtained. This is the basis for specifications of tolerances in the design of machinery parts. But although this phenomenon of variation has been known for some time, the study and method of specifying tolerances has been a subject for intuitive decision for many years, until new methods based on statistical analysis were established. It is surprising that the process of recognising the fact that most industrial engineering operations, and not only manufacturing operations, are not deterministic, took such a long time, since many industrial operations are associated with very wide variations, because of their being dependent on or related to human factors, and in biology and medicine it is well known that many characteristics and phenomena are subject to wide variations. The results of fabrication processes are usually related to comparatively small statistical variations, and perhaps their qualitative and quantitative analysis, before other statistical phenomena in industrial engineering, can be attributed to the fact that they were easier to understand and to attack.

the principle of simplification

Another phenomenon connected with industrial operations is the large number of factors and variables affecting them. In many fields of physics we can carry out experiments by isolating the system. We disconnect the system from other phenomena and proceed with the experiment in a closed system unaffected by the outside, and usually the factors which we cut off have such a small influence, that we may draw conclusions from the experiment about the behaviour of the system when it is not disconnected. This is the principle of simplification: the adequate description of the phenomenon by a minimum number of major components and disregard of all secondary components. Attempts to utilise the principle of simplification in industrial engineering have not been very successful and in recent years we have come to believe that the principle of simplification is not suitable for the study of industrial engineering operations. The large number of variables, the difficulty in differentiating between major and minor variables, the objection to isolating the system and the inter-influence of systems, situations and groups of variables, all lead to the view that the phenomena are inherently complex and not simple, and that the principle of simplification is not likely to help us very much.

This conclusion has far-reaching consequences when we want to analyse industrial problems with the aid of models. The purpose of the model is to represent in its characteristics the system which we want to analyse, and to enable us to study these characteristics by setting conditions and feeding data, which would be impossible to do in practice. If we perform the many experiments on a plant in practice, we might experience bankruptcy long before we have a chance to understand the nature of the problem under consideration. But the use of models in classical physics, for instance, is based on the simplicity of the model, whereas in industrial engineering, as we have just seen, it is necessary to build complicated models, and these can become a serious source of errors, since in order to construct a good model we have to copy reality, and in order to copy reality we have to understand it, and in order to understand it we are trying to build a model. It is, therefore, evident that the whole approach and understanding of complex systems, which are inherently complex, should be entirely different from the classical approach based on the principle of simplification, and this is one of the major problems facing the industrial engineering science.

the Hawthorne experiments

In the mid-twenties a number of experiments were carried out at the Hawthorne works of the Western Electric Company in Chicago, with the aim of finding the effect of lighting conditions on the output of workers. Two groups of operators were put into different rooms, in one of which the illumination intensity remained constant, whereas in the other it was a variable factor. The two groups were engaged

on the same task and the purpose of the experiment was to compare their outputs as the illumination intensity was changed, and perhaps to conclude about the optimal lighting conditions.

Two very interesting results emerged: first, the output of the group with the constant illumination was higher than the average output in the plant, although the illumination and the other working conditions were apparently the same. Secondly, the output of the group with the variable illumination increased when compared to the other group, both when the lighting was intensified or diminished. In other words, no direct relationship was found between the outcome and the variable factor; in this case, the illumination intensity.

The people conducting the research came to the conclusion that carrying out experiments on the basis of changing only one parameter, was not practical. Since variations in one parameter cause variations to others, they decided it was necessary to widen the scope of the experiments in order to compare the effects of various systems of working conditions. The second series of the Hawthorne experiments started in 1927 and went on for five years, when the output of five experienced operators, engaged in the assembly of telephone relays, was measured. The group worked in a special test room and the change of working conditions included changes in working hours, the introduction of a five-day week, changes in the number and length of rest pauses, supply of light meals to the operators in the rest pauses at the expense of the company, changes in wage systems, etc. It was found that the output constantly increased throughout the period of the experiments, so that at different periods, even when the working conditions were the same, the outputs were different. The output continued to increase, even when in period No. 12 the rest pauses and the free meals were abolished and the working hours were identical with those of period No. 3, but while the weekly output in period No. 3 was about 2,500 relays, the output in period No. 12 was more than 2,900. The second series of experiments led to the conclusion that it was impossible to relate clearly the output to the parameters in the test room.

Many explanations of these findings have been offered, and one conclusion, that can be found in literature, is that it has indeed been proved that physical conditions have a direct influence on output and efficiency, in spite of the fact that definite optimal conditions could not be found. It is clear that the relation between physical conditions and output is not a simple mechanistic one, since the physical conditions affect the mental conditions of the operators, and thereby the whole mechanism by means of which physical conditions are translated into output. This is how Alford and Beatty summed up the results of these experiments:

"It was learned that an individual's productive effectiveness increases with an increase in the personal satisfaction derived from the work and work environment".

Also :

"As a result of the investigations, it was learned that the most important factor in obtaining maximum sustained output was the worker's emotional reactions — his feelings toward his work, associates, supervisor, and the enterprise as a whole" 2.

We can perhaps draw from the Hawthorne experiments an even further reaching conclusion relating to industrial engineering research, especially in those fields where the human factor plays an important role. Since the carrying out of the experiment and the change of parameters change the mental conditions of the operator and his reactions, there arises the principal problem of interpretation of experimental results or, if we formulate this in slightly different terms, taken from modern physics : the very fact that an experiment is carried out, the observation and the presence of the observer, or his measuring instruments, change the conditions of the experiment, and the measured results are no longer related to that reality which we want to study, but to a different picture, a distorted one, the relation of which to reality is not known and perhaps not constant. These experiments which we carry out in industry under "normal" conditions, or those carried out in the laboratories under conditions similar to those prevailing in reality, do not, therefore, describe the original system of conditions that existed before the experimental period and these conditions cease to be "normal" the minute we start to observe them.

In laboratory tests the problem is far more serious, since not only is the measured system dependent on and affected by the observer and his observations—it is also transferred from reality in time and place and poses a very serious question : what do these experiments tell us ? May we conclude quantitatively on reality from what we found in the laboratories ? If such conclusions are allowed within certain limits, what confidence can we have in them ? If such conclusions cannot be allowed, what is the point of carrying out experiments ? These are principal questions which will no doubt greatly influence industrial engineering research methods in the future.

It is perhaps worthwhile giving a few examples in order to show the consequences of the Hawthorne effect in the field of research and measurement in industry :-

1. We want to study and modify a method of operating a certain machine, which involves redesign of the workplace layout. As we do not want to interfere with normal work in the plant, we carry out the experiments and the observations in a work study laboratory, but naturally we use all the tools of the operator, his machine and even the operator himself. We simply transfer geographically the operator's system from the shop to the laboratory. After a lengthy analysis, we define a method which we think is the best one. What confidence do we have that

this method will indeed be the best one in real working conditions, when no observation takes place ?

2. In an industrial process we have quality control performed according to a certain method. We want to check the efficiency of the inspection method as a function of its characteristics and its dependency on the inspectors. We have come to conclude that some aspects are irrelevant or insignificant. Do results of this experiment describe that reality which is unaffected by it ?
3. We want to find out workers' attitude to a specific problem, related, for instance, to human relations or to industrial organisation. We usually do this by the method of questionnaires or interviews or both. Even if we assume that the operator has no interest or wish to conceal his real feelings and views on the subject under consideration, can we really be sure that the very fact that a survey is carried out, that the actual formulation of the questions (not the way they are formulated), do not result in answers which distort that very picture which we are trying to find ?
4. Work measurement in industry, where the time study engineer uses an instrument to measure the time while watching and studying the operations of the worker, is in fact an observation, the purpose of which is to photograph reality without the influence of the observer on the nature and the characteristics of this reality. To what extent can we really rely on the obtained "photograph" and assert that no distortion has occurred due to the presence of the time study engineers, i.e., due to the fact that an observation has taken place ?
5. The organisation of a plant is being analysed with the aim of introducing modifications in its structure. The analysis reveals certain faults in the organisation, and it is decided to change it, or to suggest an entirely new structure. And, indeed, the results are desirable and the efficiency is increased. What confidence do we have that the improvement occurred because the new organisational structure is really superior to the old one, and not just because a series of changes has been introduced ? In other words, the evaluation of the results of such a change is analogous to an observation of the type that was carried out in the Hawthorne experiments, and we have to pose the question : should the positive results be attributed to the nature of the change and the skill of the organiser who initiated it, or to the change itself by merit of its being a change ?

I have purposely brought common and familiar examples from industry, the results of which we tend to accept as a basis for decision making and for planning. The Hawthorne experiments not only cast

grave doubts on the justification of this approach; they emphasise the fundamental problems connected with experimentation in fields of industrial engineering.

the meaning of administration

The conventional views on industrial management have naturally affected the whole understanding of the meaning of administration, and the approach to planning, evaluating and experimenting with problems in administrative behaviour has been labouring under the influence of the five basic concepts of the classical theory, in particular that of intuition. Treatises on administration and the exponents of its "theory" often found refuge in phraseology, generalities and rules of thumb to suit particular situations. Consider the following clichés:

The main thing is to put the right man in the right place (Taylor again ?)

Personality is more important than the position or the administration (what is personality ?)

The art of management, of leadership, of foremanship (of vagueness)

Organisational charts are the key to successful management (are they ?)

First the system, then the man, or

First the man, then the system (we have now drifted into an ideological discussion).

In the light of what has been said above, such clichés, on which industrial engineering has relied in the past, are really meaningless in the analysis of organisational systems. The "right man", the right place, communication circuits, organisation methods

or procedures — all these are not isolated deterministic systems, they are parts of complex beings and have to be studied therefore as parts of the whole and not in isolation. It would seem that we know far too little about the behaviour of such systems and a great deal of research is still required. This is of particular importance in view of the effects of technological changes on industrial organisation, such as the effects of new processes, new materials, automation, new methods of production control, etc. When we have to plan new management systems, we rely on the present or on our past experience, while in reality "new tools begin to change the task and a new task begins to change both the organisation of the task and the qualities required to carry it out successfully" 12. Our study of organisational methods must be related to the dynamic pattern of the systems, to the infinite spiral of progress, and the methods of analysis and application will have to be designed accordingly.

conclusion

The collapse of the basic concepts, on which the classical industrial engineering was built, is causing fundamental changes in the structure of this applied science and in the faculties required of practitioners in the field. It is claimed by some, and disclaimed by others, that we are now in the throes of the second industrial revolution. Be that as it may, we are certainly experiencing an industrial engineering revolution in basic theories and concepts, in analytical tools and approach.

With the emergence of the new industrial engineering, and only with the application of new scientific methods in industrial management, shall we be able better to understand, utilise and control industrial operations and systems. All this will affect our lives at least as much as any of the major technological changes that left their mark on the progress of human society.

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UNIQUE ASPECTS OF

NUCLEAR COMPONENT MANUFACTURE

by H. C. AMTSBERG,
Engineering Manager, Atomic Fuel Department,
Westinghouse Electric Corporation.

IT is the purpose of this Paper to highlight the more important, unique or specialised aspects of manufacturing nuclear components for atomic power plants. The discussion will not attempt to cover in detail all features for all types of reactors; such a comprehensive review is beyond the scope of this Paper and is totally unnecessary. Fortunately, limited experience obtained with fuel components for pressurised water reactors is, by and large, typical of the most severe and restrictive problems. More specifically, experience gained on the Shippingport reactor core can be used quite successfully as illustrative material in giving the reader guideposts for his further investigation, and judgment in determining the degree to which the factors apply to his own particular situation.

Generalisations are usually dangerous. However, we may be assured that manufacture of fuel components (heat source) is likely to involve the most complications; manufacture of components farthest from the primary system of an overall atomic power plant is the least restrictive. The most comprehensive picture of the possible unique features, and simplicity, can both be satisfactorily served by limiting the discussion to *fuel* components.

In this introduction, we have already discovered a language that may be new to some readers. Terms such as fuel components, pressurised water reactors, heat source and primary system have been mentioned. There are many others, such as isotope, critical mass, nuclear cross-section and radiation damage.

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Before going any further, perhaps it would be well to review briefly the principle of an atomic power plant. Then we can see what a fuel component is, how it is made, and what makes it unique. A review of this manufacturing will then reveal certain general features that make the business somewhat novel.

principle of atomic power

Fig. 1 is a general schematic view of a pressurised water reactor plant. Heat generated by the fission chain reaction in the reactor core is absorbed by the circulating primary coolant, in this case water under high pressure. This coolant in turn gives up heat to the secondary coolant in a heat exchanger, producing lower pressure steam for a turbine. The primary system is the distinguishing feature of a nuclear power plant, being, in effect, a replacement for the conventional fossil-fuelled boiler. Other types of reactors besides pressurised light water are, of course, under consideration or construction, such as, boiling water, sodium graphite, fast breeder, homogeneous and organic moderated. By and large, the basic principle is similar. It is more important to note that we do not know today which, if indeed any, of these will emerge as the basis for large-scale atomic power production. Their advantages and disadvantages are subjects for vigorous technical and economic discussion, and the basis of a large national development programme. Furthermore, the number and size of plants to be built is a matter of intense political debate, the outcome of which can seriously affect prognostication of anticipated fuel manufacturing volume.

reactor core and fuel components

Fig. 2 shows a cross-section of the reactor pressure vessel and core of an actual plant, the PWR Shippingport reactor. An artist's conception and a top view of this core are shown in Figs. 3 and 4, respectively. Note that the core is made up of blanket

assemblies and seed clusters. The former consists of rod bundles containing natural uranium dioxide (UO_2) as the fuel; the latter of four sub-assemblies which are joined together by welding to four spacers, which thereby form a cruciform shaped control rod channel. Each seed sub-assembly in turn consists of a number of fuel plates incorporated as integrally welded components. Each fuel plate is a metallurgically bonded assembly of Zircaloy 2 base, highly enriched uranium fuel alloy, having a Zircaloy 2* cladding. A somewhat idealised cross-section of a PWR type fuel assembly (cluster) is shown in Fig. 5; the white areas are water spaces or channels, the light grey is structural and cladding Zircaloy 2, the dark grey is the hafnium control rod and the thin black lines are the fuel alloy. Again, many other fuel materials and configurations have been considered, but a more detailed examination of the manufacture of the enriched fuel plate assembly discussed above will amply illustrate the problems.

fuel component manufacture

The fuel alloy is manufactured by means of a triple-melt inert atmosphere arc process. A charge, consisting of enriched uranium pellets and zirconium, plus necessary alloying pellets, is melted into a 4 in. diameter, 20 lb. ingot in a furnace which has been backfilled to a slight positive pressure with five parts helium and one part argon. After melting, the ingot is encased in a copper jacket, heated, forged and hot rolled into strip. After dejacketing, the strip is cleaned and chopped into $\frac{1}{8}$ in. \times $\frac{1}{8}$ in. pellets. This chopped alloy material is used as the charge for a second melting operation.

The second melting operation is identical to the first except that the resulting ingot is $2\frac{1}{2}$ in. in diameter. This $2\frac{1}{2}$ in. diameter ingot forms the electrode for the third and final consumable melting to form a 4 in. diameter ingot. The final ingot is forged and rolled as previously described. After hot rolling, the strip is cleaned by pickling in a mixture of nitric and hydrofluoric acids. It is cold rolled and pickled to final thickness. The strip is then sheared into filler blanks which are machined to final dimensions suitable for fuel element assembly.

To assure a quality product, inspections are performed at critical stages throughout the process. Before fillers are released for fuel element assembly, they are visually inspected for external defects and radiographed for internal defects. The dimensions, weight and uranium loading are carefully checked. Uranium homogeneity checks are made on the strip as well as on the fillers machined from the strip.

The fuel plate elements are made by the so-called sandwich technique, utilising recessed Zircaloy 2 cover plates as envelopes for the fuel filler. Because Zircaloy 2 exhibits highly oxidising properties, components of this material are enclosed in a protective

* A zirconium-base alloy containing small percentages of tin, nickel, iron and chromium, with impurities incompatible with low neutron cross-section or corrosion resistance held to very low levels.

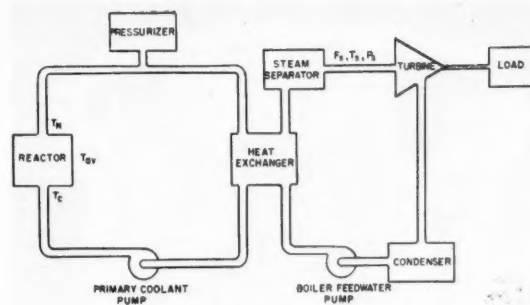


Fig. 1. Pressurised water reactor plant.

steel jacket during the hot rolling operation. The Zircaloy 2 cover plates and fuel alloy filler components are cleaned and assembled into a steel jacket, which is then welded together and evacuated. After each assembly is found to be vacuum-tight by means

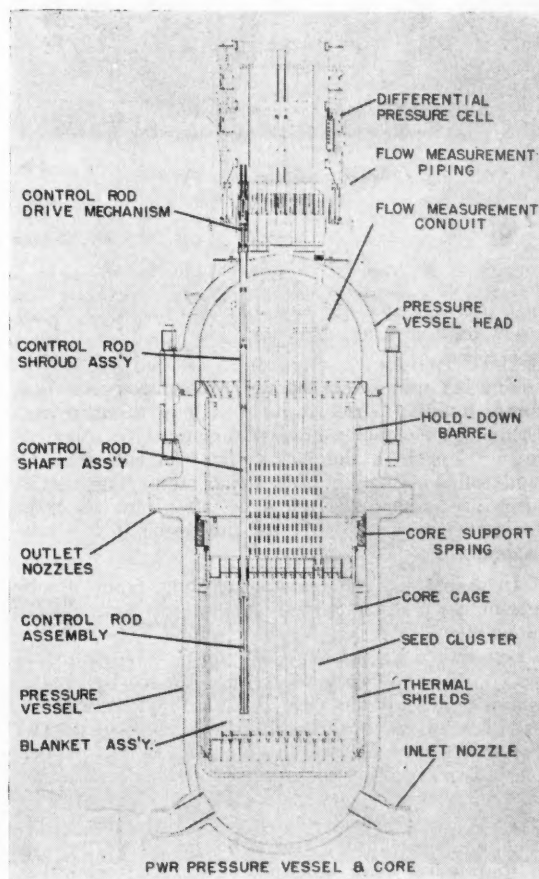


Fig. 2. Cross-section.

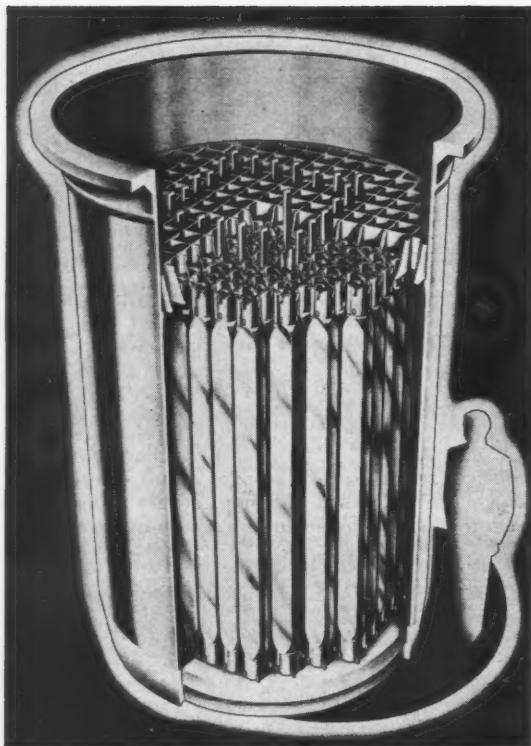


Fig. 3. Artist's conception — PWR core.

of a helium probe, the tube of the assembly is sealed by a forge welding operation. The assembly is then hot rolled.

The hot rolling schedule usually consists of several passes totalling a reduction of at least three to one. Elements of complex cross-section must be rolled to precise length in the jacket; flat elements may be cold rolled to length after dejacketing. The metallurgically bonded fuel element, after removal from the steel jacket, is ready for processing into a sub-assembly.

In preparing fuel elements for some types of sub-assemblies, it is sometimes desirable to form a flange along each edge of the fuel plate. This may be accomplished in a machine of the type illustrated in Fig. 6, where the protruding edges of the fuel plate, which is suitably clamped, are simultaneously resistance heated and roll formed into a die of the desired shape. This unique upsetting machine was developed particularly for this operation. Plates are finally prepared for corrosion test by mechanical means and by pickling in nitric-hydrofluoric acid; the latter operation being, in reality, chemical machining. Its purpose is to remove small amounts of surface metal that may have become contaminated with dissolved impurities such as nitrogen, oxygen and iron.

Surgical cleanliness of the product is maintained throughout these operations.

All fuel elements and structural Zircaloy parts are corrosion tested in high-temperature water or steam for periods usually in the range of to 3-14 days. This is accomplished in autoclaves capable of sustained operation at pressures and temperatures up to 3,000 p.s.i. and 750°F, respectively. For full-size components, autoclaves up to 14 in. diameter and 12 ft. in length are used. Coupon specimens are tested in small autoclaves. After careful examination of the part, the oxide film produced by the test is removed and a selected number of plates is stacked for fusion welding into a sub-assembly. Welding along the full length of all of the flange seams will then form a solid sub-assembly structure, as previously illustrated.

Welding of the Zircaloy components is of the non-consumable type, using thoriated tungsten electrodes. It is conducted in inert atmosphere chambers, as shown in Fig. 7. The welding chamber is evacuated through a system of mechanical and diffusion pumps to a pressure of 0.03 micron, and is then back-filled to a slight positive pressure of pure argon or helium, prior to welding. Great care must be exercised in controlling the welding operation. Under-penetration will leave partially unwelded seams which will entrap pickling acid and, subsequently, corrode; over-penetration will unduly restrict the water channels and possibly melt into the fuel alloy. Steel spacers are

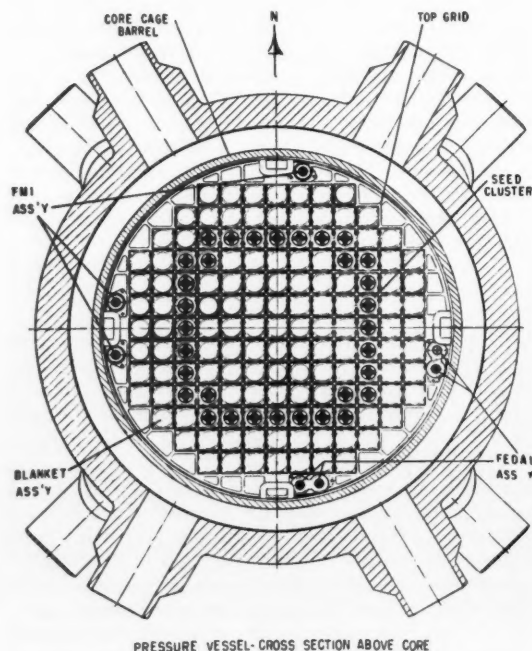


Fig. 4. Pressure vessel — cross-section above core.

frequently employed in the channels between adjacent fuel plates to restrict weld shrinkage and control distortion. They must be removed by chemical solution, following vacuum annealing and rough straightening of the sub-assembly. After welding of end brackets and finish straightening, machining and dimensional survey, the sub-assembly is given a final corrosion test. It is then transferred to the final core assembly room. Here, the fuel components are carefully assembled with the other core components control rods and hardware, to provide a complete core. A special stand, constructed solely for the purpose and containing suitable optical equipment, is used to maintain perfect alignment of the components during the assembly operation. Immaculate cleanliness precautions are observed, including carefully washed tile walls and floor, electrostatic air cleaning, controlled personnel ingress and egress and special clothing. Parts are thoroughly cleaned and kept in polyethylene bags until ready for assembly.

unique aspects

It is desirable to backtrack over this "bird's-eye" view of fuel component manufacturing to see just what is so difficult about the business, and ferret out some of the unique aspects.

In all fairness to the design engineer, it should be pointed out that he is working in a field in which research, development and manufacture have proceeded almost simultaneously and at a breathtaking pace. Each different core is a completely new encounter, requiring a prodigious amount of painstaking calculation and engineering. Even slight changes in dimensions cause severe "palpitations" among the nuclear physicists. The precision required is perhaps best illustrated by the fact that only a few pounds of fuel are actually burned during an entire core life. It is hardly any wonder, then, that the design engineer seeks perfection that tends to result in unrealistic tolerances from a manufacturing standpoint. The designer deserves the most sympathetic understanding, for he faces a most difficult task. The

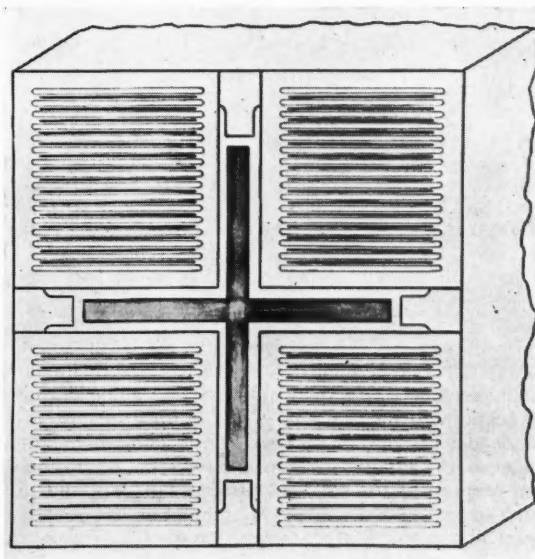


Fig. 5. PWR enriched fuel plate assembly.

volume of real experience to date is extremely limited; there are only four large power producing nuclear reactors in regular operational use today (the submarines NAUTILUS, SKATE and SEA WOLF, and PWR Shippingport).

standards and inspection

The general lack of experience has led to vague and ambiguous standards. For example, the specification for corrosion tested fuel plates states that they shall have a black lustrous temper film. You can hardly imagine the difficulty and misunderstanding that has risen over trying to answer the questions; How lustrous? and, What is black?



Fig. 6. Fuel element upsetting machine.

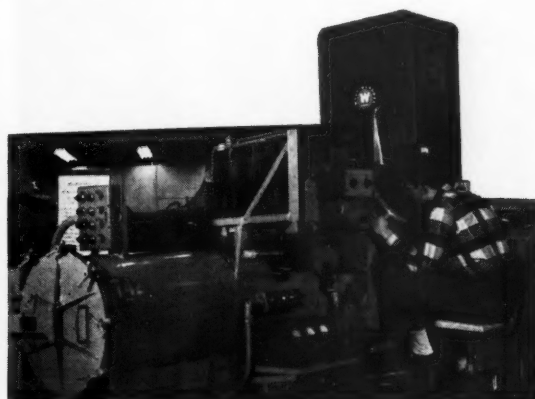


Fig. 7. Inert atmosphere welding box.

The desire for utterly complete integrity, combined with close tolerances, dictates many 100% inspections, the data from which must often be recorded and furnished to the purchaser. Typical of these are X-ray testing for defects and for fuel location to index later operations, bond integrity, corrosion testing of fuel plates and coupons, and many dimensional measurements. Specified tolerances of finished parts are so difficult to attain as essentially to preclude mass production techniques. Much of the data are used, therefore, as a basis for selective assembly. The width of each water channel of every fuel sub-assembly is determined every 2 in., the thickness every 4 in., in three discrete planes along the entire length. These, in combination with many external checks, add up to several thousand dimensional measurements for a sub-assembly alone during its manufacturing life. Figs. 8 and 9 illustrate custom-made devices that have been constructed to handle some of the unique measuring problems. A substantial amount of the total investment can be found in such special manufacturing equipment as has already been illustrated. Unfortunately, most of it is unique



Fig. 8. Sub-assembly water channel probe.

TABLE I
PRICES OF REACTOR CORE MATERIALS*

Material	Price, Dollars per lb.
Uranium — highly enriched	8,000
Uranium — natural	20
Zirconium	30
Hafnium	100
Stainless Steel	1

* Approximate 1957 figures for fabricated shapes.

to a particular core design, as well as to the atomic power business as a whole. Such equipment is expected to suffer extremely rapid technical obsolescence as a result of major design and process changes. A profound effect on plant cost is obvious.

materials

Reference has already been made to some of the more exotic materials used in nuclear reactors: specifically, uranium, zirconium and hafnium. Indeed, prior to the atom bomb programme, in the case of uranium, and the Submarine Thermal Reactor Programme for zirconium and hafnium, these materials were simply metallurgical curiosities. The world's supply totalled only a few pounds. Much remains to be learned about their characteristics and technology.

Uranium, of course, is the fuel, and through the fission or splitting of this atom, heat is generated. Zirconium is used as a structural and cladding material in the "neutron flux" region of the core because of its low nuclear cross-section (capacity for absorbing neutrons). Hafnium, on the other hand, makes an excellent control material because of its exceptionally high cross-section. These metals, when properly alloyed and fabricated, are resistant to damage by radiation. Zirconium and hafnium of sufficient purity have satisfactory corrosion resistance in pure hot water, an environment considerably more rigorous than casual thought might conclude. Table I lists approximate costs of these metals as compared with stainless steel, the only relatively common material used in cores of the type discussed here. A price for enriched uranium is somewhat a misnomer; it cannot actually be bought. For some projects, the Government furnishes it free of charge; for others, it is "rented". It may not necessarily be supplied in the quantities the manufacturer might desire for most economical processing. The other materials mentioned are either supplied entirely or mostly by the Government.

The widely divergent nuclear characteristics of these materials dictates absolutely infallible identification throughout all processing. Even if one were to consider being simply a supplier of machined components of the non-fissionable materials (zirconium and hafnium), their economic and strategic value alone demands exceptional handling procedures. All of these metals and their alloys are non-magnetic, and are also highly reactive with the principal elements

of the atmosphere, namely, nitrogen and oxygen. Both zirconium and uranium are pyrophoric in finely divided form, such as machine chips. These factors, combined with odd shapes and close tolerances, demand very clever, and frequently expensive, tooling and fixturing methods. Workmanship, house-keeping and maintenance of tools and equipment must be of the highest order. An accumulation of chips and a spark from a tool cutter will produce an intensely hot fire which can ruin equipment and plant. Chips are carefully segregated and moved, and stored under water.

For strategic reasons, and protection of the public health and safety, the Atomic Energy Commission is required by law¹ to control rigidly the distribution and handling of all fissionable material (usually called Source and Special, or SS nuclear material). The degree of control far exceeds that justified solely by the high economic value. These controls have given birth to such unique functions as "SS Accountability," "Health Physics,"² "Criticality Control"² and "Security". Any organisation expecting to handle SS materials is required to prepare detailed procedures covering each of these aspects for AEC approval. These are described in more detail in the following paragraphs.

accountability

An SS Accountability system must be established which will precisely account for the amount and location of material on both an intraplant and inter-location basis. Such information becomes a part of a national "balance sheet", and is regularly reviewed through monthly reports and semi-annual surveys and audits by Atomic Energy Commission personnel teams. For enriched uranium, data are often kept to tenths and hundredths of a gramme, but shipping records and balances are maintained to the nearest gramme. Elaborate plumbing and ventilating systems have been installed to catch a few grammes a month of what would otherwise become lost or "unaccounted for" material. In such a facility, special walls, floors and all equipment are periodically scrubbed or washed down. The tool engineer designs or specifies equipment that is readily cleaned or decontaminated.

health physics

The possible toxic effects of fissionable material necessitates a function most commonly known as Health Physics or, less frequently called, Nuclear Hygiene. Whatever the title, its purpose is to establish and police procedures and practices that will protect personnel from the contamination hazards associated

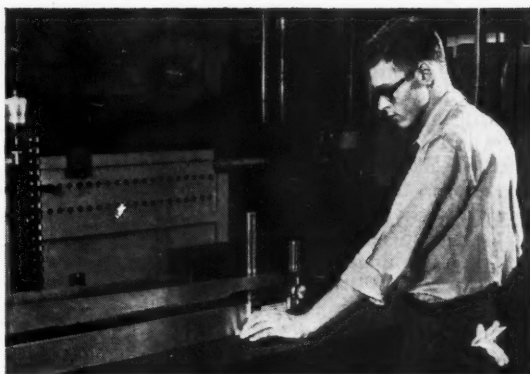


Fig. 9. Box and cluster probe.

with fissionable material. For present-day fuel component manufacture, the direct radiation hazard is essentially nil since the material is, for all practical purposes, "cold". Nevertheless, highly imaginative citizens have from time-to-time blamed virtually all their ills on their proximity to fuel plants. For example, failure of milk and grain crops, sterility and even pregnancy have been the subject of actual or potential law suits. It probably pays, therefore, to have a radiation background survey made in your plant before any operations begin, in the event such evidence is needed. While quite precise analytical procedures and instrumentation are required for this work, several firms now make a business of providing this service.

Facilities which handle bare (unclad) fissionable material, especially enriched uranium, require close control of ingress and egress, special regulations for smoking, eating and personal hygiene and special clothing. Such clothing is worn only in the operation and is left behind in going through isolated shower and change rooms. Separate laundering equipment must be installed in the facility for this clothing and other protective equipment. Effluent from the laundry, showers and wash rooms is discharged into Accountability drains. Good practice usually provides for periodic, specialised, medical examinations for employees.

criticality control

The principle of atomic energy is based on a controlled fission (or fusion) reaction. For such a reaction, it is necessary to assemble a "critical mass" of fissionable material. However, the very fact that this phenomenon is possible places severe restrictions on the manufacturing operation, and is the basis for another of our unique functions, Criticality Control. It is self-evident that the manufacturer of fuel components must, at all times, completely preclude the possibility of a critical or supercritical mass, since he has neither the conditions nor environment for control of such an eventuality. Criticality Control

1. U.S. Atomic Energy Commission, "Manual," Volume 7000, Part 7400, "Materials Accountability". The Commission, n.d.
2. U.S. Atomic Energy Commission, "Health and Safety Considerations for Uranium Fuel Fabrication Facilities" Report COO-212. The Commission, 1st December, 1957.

regulations are usually based, therefore, on "always safe" practice. They provide an adequate safety factor even if two events, each of which in itself is extremely unlikely, occur simultaneously.

Criticality areas are determined from the maximum levels of permissible fissionable material calculated for the various fuel configurations and process operations. Special material custodians have the sole authority and responsibility for movement of material between criticality areas. These can be denoted by unique, bright-coloured floor tape to contrast with regular aisle markings. The custodians are assisted by control boards on which each move is preprogrammed with tickets, before the actual shop move of real material is authorised. Wherever possible, the tool engineer designs jigs and fixtures and equipment in which it is impossible to obtain unsafe levels. Welding, annealing and corrosion test fixtures and pickling tanks are typical examples where "built-in" criticality control can be developed. Hydrogenous materials (viz., plastics) are avoided as much as possible in fixtures and handling devices because of the moderating effect of the hydrogen atom. Plant layout and equipment spacing can be seriously affected in order to optimise control. Fissionable material or components not in-process are stored in special vaults or safes, which are constructed of "always safe" design and materials. The safes are

portable and are also used for interplant shipments of fuel elements or sub-assemblies.

The remote, but nonetheless finite, possibility of a nuclear "fire" raises grave questions of property and third-party protection and liability, causing a stirring upheaval of the insurance profession. This subject has required special insurance pools and unique legislation. It is a matter that must be evaluated very thoroughly.

security

The last speciality of the business to be mentioned, namely, security, is probably more generally understood. Appropriate steps must be taken to protect classified information and materials. These usually include alarm systems, crash (one-way) emergency exits, badge-pass exchanges and the like. Clearance of employees ("L" or "Q") is obtained, and security approval of the facility by the Atomic Energy Commission is required for handling of significant amounts of SS material, even though the projects may otherwise be unclassified. The security aspect can be expected to lead to somewhat larger than average plant protection organisations. Also, the time required to "clear" employees reduces flexibility of the work force and require modified employment practices.

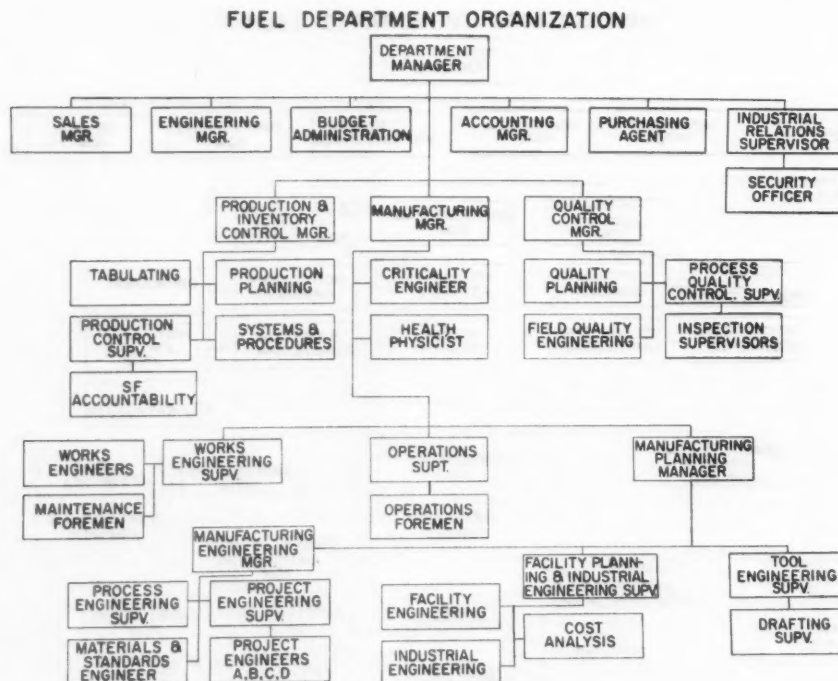


Fig. 10. Fuel department organisation.

summary

The specialised aspects and unique features of the fuel component manufacturing business can be conveniently summarised and emphasised by examining the organisation chart of a typical present-day fuel department, shown in Fig. 10. Exclusive of the design engineering function, the ratio of so-called expense or overhead to productive personnel might very well be two to one. The extensive manufacturing engineering, quality control and facility planning activities required by the unusual nature of the product are illustrated. We also note the specialised functions of SS Accountability, Health Physics, Criticality Control and Security. From this picture, let us draw a few concluding remarks.

Does the seemingly cautionary and pessimistic tone of this presentation make the business manifestly unattractive, especially for the tool engineer? Is this business strictly for "long hairs"? Not by any means. Instead, it is hoped that the manner in which the unique aspects have been described will encourage thorough planning in place of reckless daring. Let's face it—it's high time that the rose-coloured glasses be removed and industry shelves the "let's get on

the bandwagon" approach. Atomic power must be treated realistically as a tough development job. It cannot be expected to support the magnitude of business interests that have already ventured into the field.

From this author's experience in this business, two important requirements seem abundantly clear:

1. Common sense, but original and ingenious manufacturing thinking, and
2. A close, harmonious and effective working relationship between the development and design people and the production people.

These requirements are not unique to atomic power; they would be good for any business. Atomic power can profit from the best that the tool engineering profession can offer. Thus, the old adage still seems appropriate:

"If a man can write a better Book—preach a better Sermon or make a better Mousetrap than his neighbour—though he build his house in the woods—the World will make a Beaten Path to his door."

PRODUCTION TECHNOLOGY AT THE UNIVERSITY OF MANCHESTER—concluded from page 422

The latest development is the establishment of a two-year full-time course in machine tool design for which the Machine Tool Trades Association have established 10 scholarships. In this course the basic principles and the latest developments concerning the design of up-to-date machine tools will be taught by both academic lecturers and experts from the machine tool industry.

The minimum qualification for admission to the course is the Higher National Certificate in Mechanical or Electrical Engineering. Students will receive lectures on subjects dealing with performance requirements, design specifications and basic design and calculation data for machine tools; the principles of electrical engineering especially electronics; hydraulics; vibrations; friction and lubrication; control engineering; properties and behaviour of engineering materials; standardisation; metrology; ergonomics; safety regulations; economics of automation; etc. Design problems concerning machine tool structures, drive elements, slides, slideways and bearings will be discussed, and laboratory exercises, work on actual design projects and visits to the works of leading machine tool firms in the country will complete the syllabus of the course.

In view of the fact that the scholarships are to be awarded to members of staff of the machine tool industry, it has been proved impracticable at present to make this course formally a post-graduate one because of the amazingly small number of graduates employed in technical positions in the machine tool industry. The standard of the course is, however, intended to reach that of a post-graduate course.

NUMERICAL CONTROL FOR TEMPLATES AND DIES

by D. H. BINGHAM, Jr.,

Supervisor, Numerical Control Programming Section,

and R. G. CHAMBERLAIN,

Programming Engineer, G. & L. and Hypro Division,

Giddings & Lewis Machine Tool Company.

NUMERICAL control of machine tools is getting wider and wider acceptance as the results of the first commercial applications are published. In almost every case, significant improvements have been noted in part cost, lead time, and/or accuracy. These same advantages are possible with non-repetitive tool and die work.

Numerical control should not be confused with automation. The past few years have seen the word automation much used and abused by both management and labour. Generally speaking, automation is for mass production while numerical control is basically a control concept adaptable to any specific machine.

As an example of the savings possible with numerical control, approximately 1,850 different 12 ft. aircraft spar mill templates were produced at a cost of 40% of the next competitive bid. At the same time, the total time involved was about one-quarter that required by conventional manufacture. In addition, one producer of templates, using numerical control, has stated that the manufacturing errors using this system are one-quarter of those realised by conventional means, as shown in Fig. 1.

In die sinking, similar comparisons have been obtained. One study showed that machine time was

reduced from 60 to 8 hours and bench time from 12 to 2 hours, while holding dimensional variations to one-third of those obtained previously.

history

The first numerically-controlled machine tool, the result of an Air Force contract with MIT, was displayed in 1951. This system provided for a separate numerical control for each machine, necessitating the maintenance of its complex electronic system under shop conditions.

To overcome the disadvantages of this system, a Giddings & Lewis engineer conceived the idea of recording the control information on a magnetic tape in such a form that a simple machine control could read the signals and accurately position the machine.

In 1952, the Company authorised a research programme for the development of this idea. This programme resulted in public demonstrations on 6th June, 1955, which proved that this system, christened Numericord, was a workable control.

operation

The Numericord system consists of three steps (see Fig. 2) from drawing to machined part. The first step is that of processing or programming; the second step, recording on magnetic tape; and the last step, machine operation.

Programming, in turn, is divided into methods planning, which includes tool and fixture design, and encoding for computation. In methods planning, the location of the part on the machine, machine motions to be controlled, optimum feed rates, necessary auxiliary functions (such as coolant, automatic clamping and chip collecting), tooling holes, cutter sizes, and physical location of all moving elements, are established. At the same time, the cutter path is delineated.

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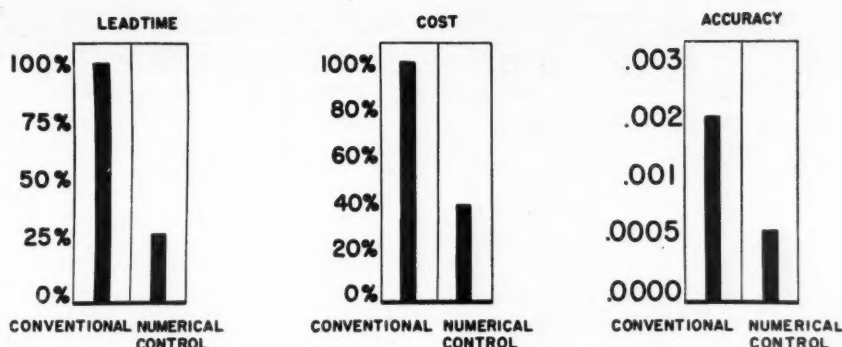


Fig. 1. Comparison chart — conventional versus numerical control.

These decisions are then forwarded to the programmer who prepares the information for input to a general-purpose computer. The programmer lists on the outline sheet all the known co-ordinates and uses a simple symbolic notation for the other points required. Thus, it is possible to programme directly from a conventional blueprint without having lengthy co-ordinate tables calculated by the designer.

The programmer also describes the cutter path, including all information on cutter diameter, direction of path around the contour, depth of cut and tolerance. This section, called Path, and the previous section, Description, comprise the input to the computer.

template manufacture

The programmer's manuscript for a section of the template just referred to is illustrated in Fig. 3. In this instance, all of the *description* elements were known, and consequently, were entered in co-ordinate form. The *path* information is entered in a manner that will result in calculation of tool offset by the computer.

This manuscript is then punched into IBM cards, one item per card, exactly as written by the programmer. These cards, the problem deck, are fed to the computer, which produces a manuscript (Fig. 4) and a deck of punched cards.

These cards are then converted to a paper tape by a card-to-tape converter. The paper tape, in turn, is the input to the Numericord Director (Fig. 5) which creates the magnetic tape. Consequently, the magnetic tape contains all instructions necessary to create the desired part when read at the machine tool.

A comparison chart (Fig. 6) indicates the advantages of numerical control over conventional manufacture. This actual example clearly indicates the lead time superiority, as well as the cost reduction possible.

Another example of using numerical control to create a template is the conversion of the manuscript for a profile template (Fig. 7) to the template itself (Fig. 8) the data being prepared

directly from the blueprint (Fig. 9). In this example, the entire production of the template involves less time than the layout (Fig. 10).

As can be seen from these comparisons, there is a tremendous reduction of lead time and machine time

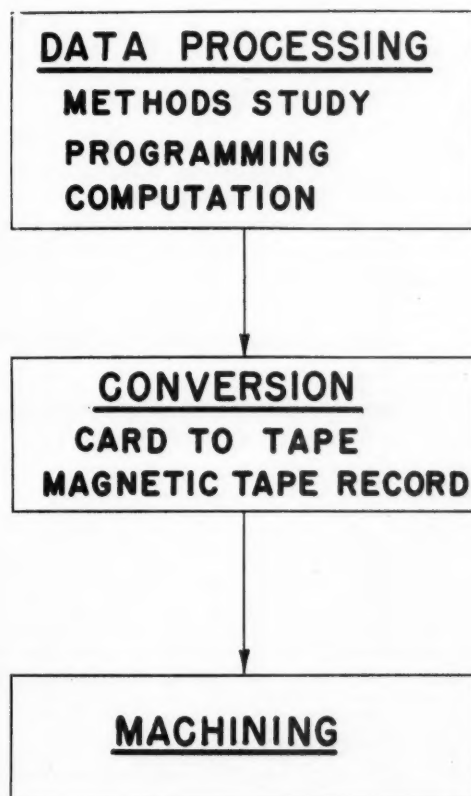


Fig. 2. Flow sheet.

JOB: BOEING TEMPLATES		OPERATION: N°1		PFT 35-2889-1		SALES NO. 44142		DUE DATE: _____	
PROGRAMMER: D.J.W.		DATE: 7-18-57		DIRECTOR CLOCK: 1.00		SPECIAL INSTRUCTIONS: _____			
EDITOR: M.C.D.		DATE: 7-18-57		HEAD OFFSET: _____					
KEYPUNCH: _____		PATH DUE: _____							

0

DESCRIPTION	SPEED	GEOM.	POINT	Z-ORDINATE	S-ORDINATE	H-ORDINATE	TOOL RAD	TOLER	R	PATH EXPLANATION
P99 = +7.0000, +8.0000	000 00		P99	+ 2 0000	+ 0 0000	+ 0 0000	0 560	0100	0	
	X 46									
	X 01									
	X005									
P00 = -145.0000, +8.0000	30 00		P00	+ 0 0000						
P01 = -145.0000, +3.4500			P01						L	
P02 = -115.5620, +3.4500			P02							
P03 = -112.5620, +4.2000			P03							
P04 = -77.0620, +4.2000			P04							
P05 = -74.4640, +5.7000			P05							
P06 = 0.0000, +5.7000			P06							
P07 = 0.0000, 0.0000			P50				0 500		0	
P08 = -144.0000, 0.0000			P06						L	
P09 = -144.0000, +3.4500			P07							
P50 = +1.0000, +8.0000			P08							
			P09							
			P02							
			P03							
			P04							
			P05							
			P06							
				+ 2 0000						
			P99						0	
	X 00									

Fig. 3. Programmer's manuscript for aircraft spar mill template referred to in the Paper.

1 -	.0050		6	.1495		6	.0415		1507
1 -	.0045		6	.1500		6	.0410		1506
1 -	.0045		6	.1495		6	.0415		1507
1 -	.0050		6	.1500		6	.0410		1508
1 -	.0050		6	.1495		6	.0415		1509
1 -	.0045		6	.1500		6	.0410		1510
1 -	.0050		6	.1495		6	.0415		1511
1 -	.0050		6	.1500		6	.0410		1512
1 -	.0050		6	.1500		6	.0410		1513
1 -	.0050		6	.1495		6	.0410		1514
1 6	.0075		6	.1480		6	.0435		1515
1 6	.0060		-	.1495		-	.0420		1516
1 6	.0065		-	.1500		-	.0420		1517
1 6	.0065		-	.1500		-	.0420		1518
1 6	.0080		-	.1495		-	.0425		1519
1 6	.0065		-	.1495		-	.0420		1520
1 6	.0080		-	.1500		-	.0425		1521
1 6	.0060		-	.1495		-	.0425		1522
1 6	.0080		-	.1495		-	.0425		1523
1 6	.0060		-	.1495		-	.0425		1524
1 6	.0080		-	.1500		-	.0425		1525
1 6	.0055		-	.1495		-	.0430		1526
1 6	.0060		-	.1495		-	.0425		1527
1 6	.0055		-	.1495		-	.0430		1528
1 6	.0055		-	.1495		-	.0430		1529
1 6	.0055		-	.1495		-	.0430		1530
1 6	.0050		-	.1495		-	.0430		1531
1 6	.0055		-	.1495		-	.0430		1532
1 6	.0050		-	.1495		-	.0435		1533
1 6	.0050		-	.1490		-	.0430		1534
1 6	.0050		-	.1495		-	.0435		1535
1 6	.0050		-	.1495		-	.0430		1536
P30	1 6	.0055	-	2.8095		-	.0425	-	.6780
P31	1 6	.0010	-	2.8085		-	.0350	-	.6130
P32	1 -	.0005	-	2.8090		-	.0260	-	.6395
P33	1 6	.0000	-	2.8090		-	.0190	-	.6585
P34	1 6	.0000	-	2.8090		-	.0120	-	.6695
P35	1 -	.0005	-	2.8095		-	.0045	-	.6740
P36	1 6	.0000	-	2.8095		-	.0025	-	.6740
P37	1 -	.0005	-	2.8100		-	.0105	-	.6600
P38	1 6	.0000	-	2.8100		-	.0180	-	.6420
	1 6	.0000	-			-	.0260	-	.6440

Fig. 4. Manuscript from computer.

inherent in numerical control. The actual ratio is of the magnitude 1 : 10.

die sinking

Similar benefits have been obtained in sinking a typical die (Fig. 12). As can be seen, this is a small cavity which embodies straight lines, circular segments and deep, narrow ribs.

With normal techniques, this die would require layout, templates, and a relatively skilled operator. With numerical control, however, these requirements are eliminated. The blueprint furnishes all necessary information for the calculation of the tool path by a general-purpose computer; the output of the computer, when converted on to a magnetic tape, constitutes instructions for the machine tool.

The normal die print developed by the tool engineer from the part print is shown in Fig. 11. In this print, allowances have been made for metal flow and for shrinkage.

From this print, the methods planner creates the methods print and the methods planning sheet (Figs. 13 and 14). The methods print here is shown separately for clarity, but in normal practice is designated by cross-hatching on the die print.

The methods planning sheet includes a detailed list of the operations in their proper sequence and related information on tools, speeds, and so forth. Utilising the information contained in this sheet, the programmer can quickly designate the tool path in simple symbolic notation. The symbolic information then is processed, as outlined above, to result in a magnetic tape from which the cavity is sunk.

Copies of the planning sheet and the computer output manuscript are furnished to the machine operator to enable him to perform the operations as planned.



Fig. 5. Numericord Director.

Since all the necessary instructions are recorded on the magnetic tape, the sinking process proceeds without time-consuming delays, a majority of the decisions having been made by the tool engineer. In this way, percentage machine utilisation is greatly increased, as can be seen from Fig. 15.

Another advantage of numerical control in this work lies in the realisation of more nearly optimum cutting speeds and chip loads. This results, of course, in greater tool life and minimum breakage.

Where duplicate dies are required, an even greater saving is realised, since the instructions are readily available from the magnetic tape.

conclusions

While numerical control is very competitive with conventional manufacture at the present time, it is still a relatively new development. Improvements that

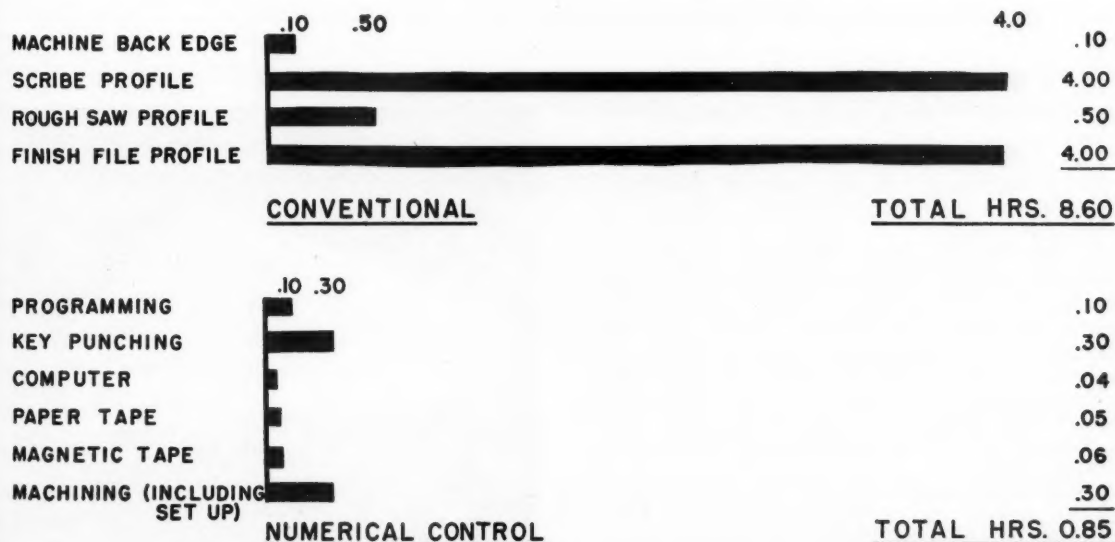


Fig. 6. Time comparison, spar mill template.

JOB: F-100 TWO-S'S

PROGRAMMER: AMM

EDITOR: RGC

KEYPUNCH: RG

OPERATION: 064 POCKET

DATE: 2-15-57

DATE: 2-15-57

PATH DUE:

SALES NO:

DUE DATE:

SPECIAL INSTRUCTIONS:

DIRECTOR CLOCK: 1.0

HEAD OFFSET:

DESCRIPTION	SPEED	GEOM. POINT	Z-ORDINATE	S-ORDINATE	H-ORDINATE	TOOL RAD.	TOLER.	R	PATH EXPLANATION
P01 = -25.7910 , -12.7380	000 00	P01	+ 2 0000	+ 0 0000	+ 0 0000	1 000	.0010	0	
P02 = -43.6130 , +11.5270	X35								
C01 = P01 , 1.3125	X02								
C02 = P02 , 1.3125	X200								
L03 = TC02 / TC01	X79								
L04 = +0.0000 , -3.3440 →	X005								
-10.0000 , -3.3440									
P03 = L03 / L04									
P04 = -58.2840 , -11.9685	10 00	P20							L
L01 = P04 → P03			+ 0 1140						
L02 = -52.5085 , +0.0000 →		P14	+ 0 0640						
-52.5085 , -5.0000		P15							
L05 = AC03 / AC04		P16							
C03 = (-133.1860 , -7.0640) , 1.1250		P17							
C04 = (-58.2840 , -12.5300) , 1.1250		P13							
L06 = -38.0220 , +0.0000 →		P14							
-38.0220 , -5.0000		P18							0
P07 = -43.4440 , +1.7550		P19							
P08 = -35.1470 , -7.7785			+ 2 0000						
P09 = -45.4615 , +0.0000		P01							
C05 = P07 , .3435									
C06 = P08 , .3435									
L09 = AC05 / AC06									
C07 = P07 , 5.6875									
C08 = P09 , 5.6875									
L10 = TC08 / TC07									
P11 = L09 / L10									
C11 = P11 , 3.0000									

Fig. 7. Manuscript for profile template.

are foreseeable for the near future will result in even greater savings.

One of the apparent advancements is the development of additional computer routines. Such programmes will result in a further reduction in make-ready costs.

At the present time, computers capable of producing machine tool instructions from symbolic notations are readily available throughout the United States for accounting purposes. These machines generally can be adapted, without modification, to numerical control work. However, companies not having access to such equipment can secure such services from programming centres that have been established by various machine tool and control manufacturers.

These centres will perform the entire data processing, if desired, or will work from the methods planning sheet provided by the customer. In either case, substantial savings are possible now with numerical control.

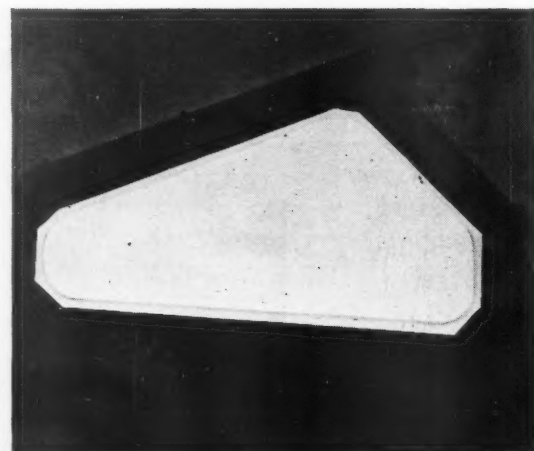
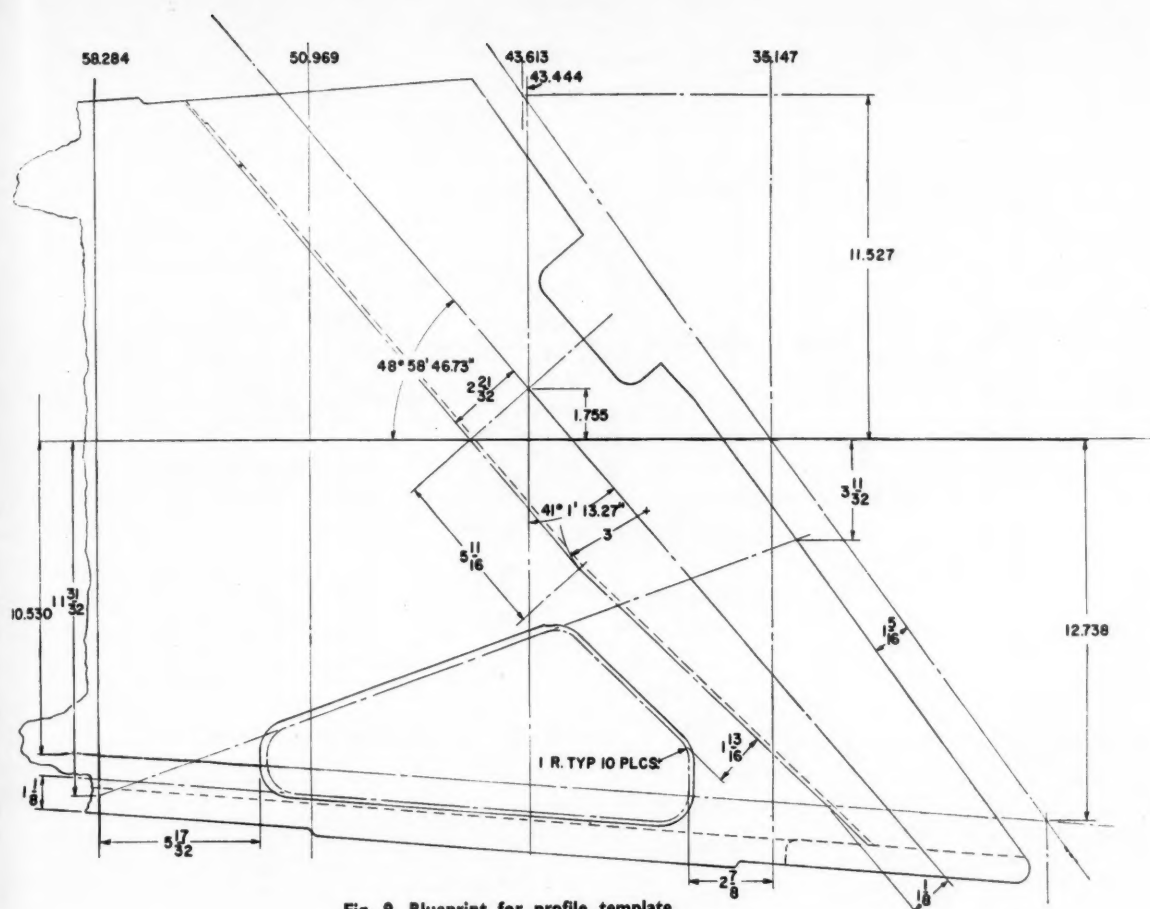


Fig. 8. Profile template.



LAYOUT		12.00
ROUGH SAW		.50
FINISH FILE PROFILE		3.00
CONVENTIONAL		TOTAL HRS. 15.50

PROGRAMMING	.75
KEY PUNCHING	.30
COMPUTER	.05
PAPER TAPE	.04
MAGNETIC TAPE	.02
MACHINING (INCLUDING SET UP)	.10
<hr/>	
NUMERICAL CONTROL	TOTAL HRS. 1.26

Fig. 10. Time comparison chart for profile template.

JOB: KAISER DIE		PLANNER: D.WEGENER		DATE: _____		CODE: _____	
SALES N°: _____		DATE DUE: _____		REVISION: _____		<div style="border: 1px solid black; width: 40px; height: 40px; display: flex; align-items: center; justify-content: center;"> <div style="border-top: 1px solid black; border-right: 1px solid black; width: 20px; height: 20px;"></div> </div>	
MACHINE: 3 AXIS VARIAX (LOW SPEED)		LOADING POSITION: +18.0000, +0.0000, +3.0000					
FIXTURES: NONE		X-CODES: X46, X04		SPECIAL INSTRUCTIONS: _____			
TOOLS: AS SHOWN ON DRG. 1		MATERIAL: DIE STEEL					
COORDINATE ZERO: ON DRG. 2		MATERIAL SIZE: 22" x 16" x 8"					

N°	OPERATION	TOOL	CUTTING HEAD	SPINDLE SPEED	H.P.	A	MAXIMUM FEED, IPM	SWIVEL OR CHUCK POSITION	TILT OR TURRET POSITION	ANGLE PLATE POSITION	DIRECTOR CLOCK
0	ORIENTATION 200 SECONDS OVER POINT OO, MOVE TO LOAD XOO							40.00			I
1A	ROUGH MILL ENTIRE DIE TO .095 DEPTH XOO	1		160	.406	1.45	1.92				
1B	ROUGH EARS LABELED "A", LEAVE .031 FINISH STOCK (SEE DRG. 2) XOO										
1C	ROUGH & FINISH BOTTOM AREA "B" (SEE DRG. 2) ALSO FINISH PLATEAU AREA C XOO										
1D	ROUGH & FINISH DEEP POCKET "D" XOO										
2A	FINISH EARS LABELED "A" TO DEPTH AS WELL AS 5° TAPER, ALSO FINISH EDGE OF AREA "B", XOO	2									
2B	MILL QUARANT AREA "E", .030 FEED PER PASS, RUN TAPE 9 TIMES, ON 10TH TIME BACK AWAY .015 XOO	5		320	.064		1.94				I

Fig. 14. Methods planning sheet.

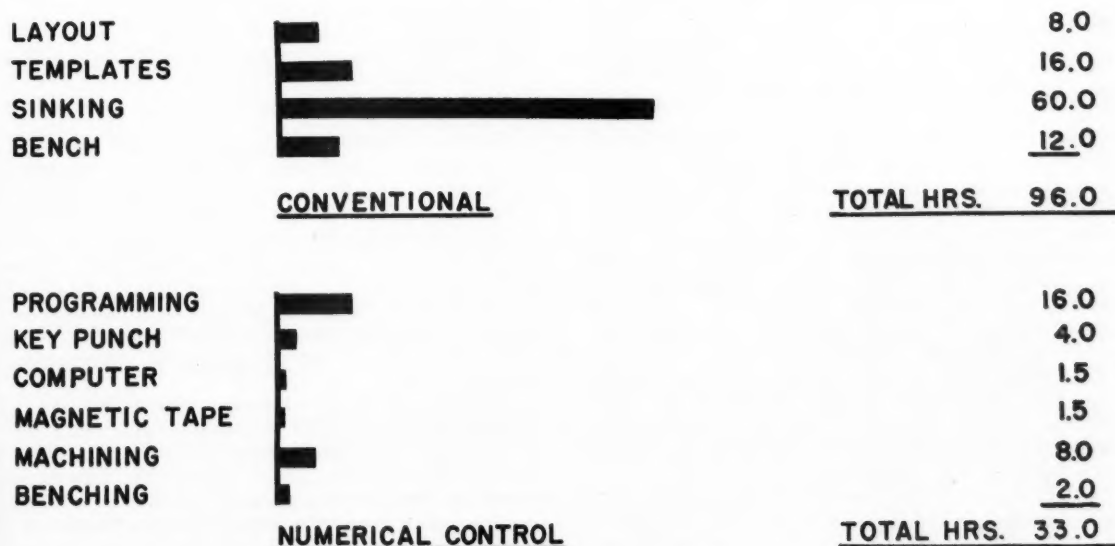


Fig. 15. Comparison chart — die cavity.

AUTOMATION

ITS DEVELOPMENT AND EFFECT

by J. R. CAMPBELL, A.M.I.Mech.E., A.M.I.Prod.E.

A Paper presented at a Course in Management Studies
at St. Andrew's University, 8th September, 1958.

WE are all aware that a large number of new words have been universally adopted in recent years, but few have given rise to as much speculation as the word automation. As interpreted by journalists and popular writers it has given rise to dreams of automatic factories operated by robots and accompanying fears of redundancy, disruption and overproduction. Much of this has been exaggeration and some of the fears may prove to be without foundation.

The word was first used in 1946 by D. S. Harder, Vice-President in charge of Manufacturing of The Ford Motor Company, Detroit, to describe a number of automatic workfeeding and material handling devices then introduced.

The American, John T. Diebold — well known for his writings on automation — also claims to have used the word as a simplification of the more difficult word "automisation".

Since then, much has been said on the subject and various arguments have been put forward, with a view to proving that automation is nothing new and merely a continuation of the process of mechanisation which has been going on since the Industrial Revolution. The acceptance of this argument could be dangerous if it prevents us from realising that the introduction of automation presents a host of problems, not only to management and labour but to the relations between them.

Trying to define automation is not a simple thing, as was obvious when an American Congressional Subcommittee held hearings on the problems of automation in 1955. Among the witnesses, 24 experts each gave his own definition.

I would quote the description given by L. D. Miller, Associate Editor of the American Magazine "Automation," in a recent Paper given to the American Society of Mechanical Engineers. Showing the

difference between automation and mechanisation he says :- "The line between them seems to be reflected best by an evaluation of the number of routine human actions in each phase of the function being performed. Where the number of routine human actions is low, most of us would consider the operation as an example of *automation*. Where the number of routine human actions is sizeable we would consider it an example of *mechanisation*, if mechanical aids are used."

development

In the development of automation we can recognise three basic forms :

- (a) integration;
- (b) feed-back control;
- (c) computer technology.

The first of these could be described as "*advanced mechanisation*" and one of the early examples appeared in a series of articles, published in 1925, describing the semi-automatic continuous machining of cylinder blocks, flywheels and gearboxes at the Morris Motor Company's works in Coventry. It was unfortunate that this pioneering effort, the forerunner of the modern transfer lines in the automobile and other industries today, suffered from difficulties which resulted in it being replaced by conventional machine tools.

Another example of an integrated line appeared in Milwaukee around 1930. This was a fully automatic line making 10,000 automobile chassis per day. There were nine separate units linked by automatic handling, for inspection and rejection, cleaning, bending, drilling and painting of incoming steel strip.

As far back as 1782 we find one of the earliest integrated systems in the continuous process flour

mill built by the American, Oliver Evans, at Philadelphia.

It can therefore be seen that the principle of "flow production" is characteristic of integration and for many years it has been the basis on which the chemical, oil and similar industries have been engineered.

feed-back control

This form of automation also has a history stretching back over the last two centuries, and the centrifugal governor invented by James Watt (1788) to regulate the speed of his steam engine, illustrates the principle whereby any increase or decrease in the required speed brings about the movement of a system of levers which operate the throttle valve, and tend to open or close it as "instructed" by the governor.

The term, "feed-back", might be simply described as "self-correction". It implies that a system is capable of adjusting itself to produce a desired performance.

The term, "closed loop", which is often encountered in this connection, implies that human intervention is not required to complete the control loop or system.

Other obvious examples are the thermostatic controls found in heating systems, and as far back as 1830 a patent was granted to Andrew Ure of Glasgow covering "an apparatus for regulating temperature in vapourisation, distillation and other processes".

At Edinburgh, in 1870, A. B. Brown of Rosebank took out a patent for a hydraulic steering device and the company which he founded, together with Denny's of Dumbarton, have recently been responsible for the design and manufacture of the "Denny-Brown" stabilising system which controls or governs the rolling motion of ships at sea.

There are several other early examples which illustrate the principle of feed-back, but modern applications are very much more complex and

although a number of the devices used today, such as photo-electric cells, electromagnetic relays and servomechanisms, were invented before the First World War, we had reached the stage of a Second World War before their potentialities were considered seriously.

computer technology

The third form of automation may well be the one which will offer the greatest benefit, although it should be clearly understood that a computer depends on the human intelligence which directs it and its value to the user rests largely on the experience, background, skill and imagination of those who prepare its instructions. The popular description "Giant Brain" is possibly an injustice, if we consider the tragic consequences which can result from man using his intelligence wrongly for his own selfish ends.

The modern computer can trace its ancestry back earlier, but it was 1823 before Charles Babbage developed his difference engine, which he was unable to manufacture because of the engineering difficulties.

Lord Kelvin also carried out developments along these lines and in the late 1920's Vannevar Bush and his colleagues, because of the developments in manufacturing techniques and electrical technology, succeeded in building a differential analyser, capable of solving differential equations.

This was followed by other machines, although these were mainly limited in speed and flexibility, a difficulty which was overcome by the developments in the field of electronics during the last War.

post war developments

In Europe and America today we can see many examples of these three types of automation and the examples quoted will illustrate their application, alone or in combination, to a wide variety of industries.

Mr. Campbell was educated at St. Mungo's Academy, Glasgow, and commenced his apprenticeship with Rolls-Royce Ltd., Glasgow, in 1940. He joined H.M. Forces at the end of 1943, served in R.E.M.E. and was commissioned in the Royal Engineers (Transportation Branch).

On leaving the Army in 1947, he studied engineering at Glasgow University and obtained practical experience in production engineering with local firms. He was engaged on machine tool and jig and tool design at The Singer Manufacturing Co. Ltd., Clydebank, until 1954, when he took up an appointment as Sales Engineer in Scotland. At the beginning of 1958, he was appointed Group Machine Tool Engineer for Rolls-Royce Ltd., Scottish Factories.

Mr. Campbell recently relinquished this appointment and is now a Machine Tool and Production Consultant.



The first example is a Soviet piston factory which can supply aluminium pistons for the whole of the Russian light car industry. With a labour force of nine workers per shift, the controller, five maintenance men, two machine minders and a labourer, it produces 3,500 pistons every hour.

The labourer feeds the aluminium ingots to a conveyor which tips them into an electric furnace. Batches of the molten metal are automatically weighed, run into the moulds and the castings automatically ejected after cooling. Having passed the automatic hardness testing section the castings are transferred through the turning, boring, grinding, grooving and polishing stations. In a chemical section they are degreased, washed, tin plated and polished again. After final inspection the pistons are automatically greased, wrapped, boxed and stacked ready for despatch. It is claimed that production costs have been halved, the manual work involved is one-sixteenth of the original amount and the factory staff has been reduced to one-quarter of the original total.

Transfer line machines have also been widely introduced in the motor car industry and the Renault Company in France can claim to have the widest application of this technique. The Volkswagen plant in Germany is a good example of automatic transfer machining and much publicity has been given to the numerous other installations in America and Russia.

In this country the Austin Motor Company was the first firm to go in for automation on a large scale. They started in the early 1950's and were soon followed by the other major firms. In the last few years companies like Ford and Vauxhall have been spending large sums of money, quoted as £65 million and £36 million respectively, on transfer lines and other machinery for automation. The latest announcement concerns an in-line transfer machine for milling and drilling, which was recently completed in the South of England. It is claimed that this is the largest machine of its type to be built in this country, being 140 ft. long and having 51 stations, 37 of which are machining stations.

Automation on assembly lines has also received a great deal of attention and in the Ford "Mercury" plant at Rivera, California, 800 motor car bodies in various stages of assembly are handled on 100 conveyors, three-and-a-half miles long, while assembly, painting and trimming take place.

Another remarkable performance is quoted in the radio industry, where the use of printed circuits speeds up the assembly of components. It is interesting to note that although greater progress in this technique has been made in the U.S.A., the first patent for printed circuits was taken out in Britain about ten to twelve years ago — by Dr. Paul Eisler, but America had at that time better facilities for producing the raw material. In 1947, J. A. Sargrove, of England, developed fully automatic circuit-making equipment for radio chassis with printed circuits, and although this was not a commercial success, it foreshadowed the concept of automatic T.V. chassis manufacture in America. A case has been quoted of a machine that assembles in little over a minute the

same number of circuit assemblies that a worker can assemble in a day. The machine requires only two workers and a supervisor and can produce over 2,000,000 assemblies a month.

oil, chemical and other processing industries

In the early days of chemical plant operation, most engineers usually lacked a knowledge of chemical processes and tended to develop processing plant based on laboratory apparatus which had been set up for batch production.

However, in 1918, A. D. Little and others at the Massachusetts Institute of Technology, put forward the thesis that all processes of chemical manufacture could be broken down into "unit operations" such as fluid flow, heat transfer, evaporation, etc., and laid the foundation for the design of plant for "flow production". Other people like Solvay in Belgium, and Mond in Great Britain on the ammonia-soda process, were exceptions to the then existing use of the "batch production" system.

Since then the processing industries have produced a number of outstanding examples of automation and experts claim that 80% - 90% of the oil industry has been automated.

At the Esso refinery at Fawley, near Southampton, six men per shift operate distillation plant which handles five-and-a-half million gallons of crude oil each day. This is equivalent to one-third of the total required for the British market. There is a total of 3,000 workers, 800 of whom are operators and approximately 1,600 maintenance men. The plant is valued at £40 million. Flow, temperature, pressure and level are controlled by automatic instruments and many of these instruments illustrate communication and control on the feed-back principle.

In the metal industry we can see the "Flowcast" method of continuously casting iron bar, which is later used for the automatic machining of cast iron parts.

The Kenya Coffee Company of London have recently installed a new plant which can blend, roast, grind and pack up to five million pounds of coffee a year.

computers and data processing

The growing use of computers in industry and commerce may well prove to be one of the most important aspects of automation and is likely to be a tool which will become a necessity for management teams of the future. Computers fall into two basic types, known as digital and analogue. Whereas the digital computer operates by counting numbers or digits, the analogue machine arrives at its solution by measuring quantities rather than by counting them.

Digital computers have been applied extensively to office routine, where justified by the amount of work available, and an interesting application in this country is the installation known as "Leo" at the head office of Messrs. J. Lyons & Co. Ltd., Cadby Hall. Development work was started in 1947 and by 1954 it was handling the payroll for 10,000 employees in a matter of 4 hours a week, a task

which previously occupied 37 full-time clerks. By the end of 1955, it was also handling the payroll for another large firm. Besides this, it handles daily orders for more than 150 branch shops, and prepares all data and records for production, assembly, packing, accounting, etc.

In America the Bureau of Mines, in its new data processing centre, now produces in 10 days a report which previously required six month's effort.

Other examples of computer applications are the "Intelix" system of the Pennsylvania Railroad Co., and the "Reservisor" system of American Airlines in New York. Both of these are examples of automatic ticket reservation handling systems and in the case of the "Reservisor", is interrogated, on average, 35,000 times a day.

A recent report describes an I.B.M. computer which has been applied to the task of indexing the writings of St. Thomas Aquinas. It was estimated that this work might have taken several experts up to 50 years to complete. With the computer and ten men the work was completed in some five years. It is hoped to carry out a similar task on the recently discovered Dead Sea Scrolls.

In science and industry the application of computers to difficult problems arising in research is proving very valuable, and a great deal of work is being done at present on the development of an automatic master controller for process control in the chemical and similar industries.

An important development in the engineering industry has been the application of electronic control to machine tool operation. Computer control of a machine tool was first carried out at the Massachusetts Institute of Technology in 1951. In this country Ferranti have carried out much development work on digital control systems and there are now a number of machine tools with the Ferranti system in use in industry. E.M.I. Ltd. of Hayes, Middlesex, is another Company doing valuable development work on analogue control systems and many well-known British and American machine tools have been fitted with the E.M.I. system, which has the advantage that it does not require an external computer for the majority of programming operations.

In the Ferranti system, information concerning the operations to be performed, speeds, feeds and other relevant data are fed to a computer by punched tape or cards. The computer then produces a magnetic tape which is used to control the operation of the machine tool *via* servomechanisms, counting apparatus and feed-back controls.

This type of machining has proved of value in the aircraft industry for the economic and accurate machining of small quantities of parts of intricate shape or contour.

advantages and disadvantages

The advantages of automation may be summarised as follows :-

- (a) It lowers production costs by reducing the handling of parts and direct labour costs.

For instance, Austin Motors claim to have reduced the labour costs on the machining of cylinder blocks from £2 17s. 2d. to 11s. an hour.

- (b) Greater production per machine or unit is obtained by eliminating delays due to such things as loading and unloading.
- (c) Quality is improved by reducing risk of damage in transfer and allowing tighter control over sequence of operations.
- (d) Safety is increased considerably and materials which would normally be too hazardous to process can be dealt with, e.g., fissionable materials.
- (e) Operator fatigue is reduced.
- (f) Lower inventory of work in progress.

Considering the disadvantages, we generally find that the initial capital required is very large and in operation maintenance costs are invariably higher. Automated installations are relatively inflexible but a great deal is being done to increase the flexibility by the application of computer control, unit construction in machine tools and plant and emphasis on the importance of early and detailed planning; although in this aspect it may be necessary to increase the technical content of the management team.

industries likely to be affected

When we come to consider the industries which are likely to be affected by automation, there are obvious exceptions like the fashion and clothing industry, and the agricultural industry, which will become highly mechanised but is unlikely to achieve automation.

Since the major applications of automation to date have been based on "flow production", the early developments have tended to appear in the process industries such as oil refining, chemicals, steel, paper, plastics, food, etc., and this trend is likely to continue.

On general administration and clerical work, data processing systems based on digital computers are being widely adopted and it is expected that this application will be speeded up over the next few years.

In the manufacturing and assembling industries the application of the "transfer" principle is likely to spread as installations become more flexible by the use of standard unit parts, and by the application of computer control. As the use of computers on routine clerical work is increased, managements will begin to apply them to the other problems of control and communication which require a solution before integration can be made effective.

An important industry in these Northern latitudes, which in the past has not been given much consideration when discussing automation, is the ship-building industry, but recent announcements from both Ferranti and E.M.I. describe electronically controlled flame cutting machines operated by tape, which are expected to revolutionise shipyard technique.

large and small firms

In the past, large firms with their capital resources and development facilities have tended to be first in the field of automation, but since the War the growth of companies manufacturing and marketing standardised equipment for automation has been large and this equipment is now available to all firms, regardless of size. It is noted that the companies manufacturing computing and control equipment expect that the smaller firms will be an important source of business in coming years.

In the U.S.A. a company employing less than 600 people is reported to be using a computer to speed up cost accounting, payroll preparation and other similar tasks.

rate of adoption

If we consider that the output of British industry rose by only 5% between 1937 and 1948, and by 20% between 1948 and 1954, with the figures for America approximately the same, then we are not likely to be concerned by the high speed of technical change.

Nevertheless, a recent Board of Trade enquiry into automation in British industry reports that a big increase in the use of automation equipment during the next four to five years is forecast. To meet anticipated demands, machine tool and mechanical handling equipment firms expect to double their output of such equipment in the next five years, and in the control equipment and computer manufacturing industries, production increases of five to six-fold are forecast for the same period.

But even larger increases in the output of automatic plant may be necessary, if the rate of adoption is to be speeded up considerably. This is borne out by the experience of companies such as Renault and Austin, who found it necessary to build the larger part of new automated plant themselves, and others like Ford and Vauxhall who had to split their orders over several large British and Continental machine tool manufacturers to ensure a reasonable delivery time.

We should bear in mind also the figures given by the Scientific Manpower Committee in 1956 :-

"On the basis that an increase in productivity bears a 1 to 1 ratio to the increase in technical trained manpower, and assuming a 4% increase in productivity, we require 220,000 technologists in 1966 against the existing output of 135,000—an increase of more than 60%."

From these and other published facts, most experts are of the opinion that automation will be adopted in a relatively slow and orderly manner, with the invariable exceptions that prove the rule.

automation as a philosophy

In an article recently published in this country, John T. Diebold has this to say :-

"Automation is as much a way of thinking as a way of doing—it is a new way of organising and analysing production, a whole new philosophy of design and production as well as new technology of machine control."

This idea has been put forward by another expert on the subject as follows :-

Automation is evolutionary in three basic aspects :-

- (a) acceptance of the concept;
- (b) techniques for applying the concept;
- (c) hardware to implement the concept;

and of prime importance :-

- (d) acceptance of the concept by industrial management.

Some of the principles expressed here are receiving much attention in the growing fields of *operational research* and *cybernetics*, a word derived from the Greek meaning "Helmsman" and popularised by Norbert Weiner in his book: "Cybernetics, Or Control and Communication in the Animal and the Machine,"—published in 1948. A later book, published in 1950, "The Human Use of Human Beings"—discussed the impact on society of the mechanisation of control and communications.

In a Paper read in May, 1958, at a Conference of The Institution of Production Engineers, Dr. F. H. George, of the University of Bristol, says that cybernetics is a general name for the study of all control and communication systems; that operational research might be said to include cybernetics; and that automation is applied cybernetics. He goes on to discuss and suggest scientific methods, which he describes as methods of systematic commonsense, which managements will require to use if they wish to guarantee success in the application of automation.

The necessity for this new approach by management is borne out by the experience of an American Middle Western manufacturer of motor car chassis, who in 1952 began to plan a highly automated line for the production of frames for a 1955 model car. The plant included a 39-station riveting and welding transfer line for assembly of the chassis, and a new factory was erected in northern Illinois. Production was scheduled to start in the middle of 1954 and achieve an output of 200 frames an hour. Despite the fact that the plant was installed in time, a series of mechanical difficulties prevented it being operated properly. For instance, one 30-foot station was found to be $\frac{1}{4}$ in. out of line and preventing the operation of transfer mechanism. Difficulties continued throughout 1954 and eventually the company had to instal conventional type machine tools to meet delivery promises. This meant that they had to find a labour force of 2,500, instead of 1,000 as originally planned. The company then realised that they were in an area with a shortage of skilled labour and a history of poor industrial relations. The company managed to maintain production schedules with the extra plant while the automated line ran at a reduced speed during the first half of 1955. Because of production pressure, they were unable to rectify fully all the engineering faults and they had finally to shut down the line and rebuild—a task which occupied the whole of the next year.

The line was started up again early in 1957 and ran without any trouble, giving a much higher

production rate than originally planned, but later in the year, when the 1958 model of the car was announced, it had been redesigned around a welded chassis.

The estimated loss on this venture was over £3,000,000, and when we look for the reasons, we find that the company in question has a first-class record, is well organised, experienced in its own field and has adequate capital available. It would appear, however, that they seriously underestimated the problems involved and did not allow sufficient time for planning and development.

This company is not the only one to have encountered such difficulties, and in Britain the Standard Motor Company ran into serious labour trouble when it introduced automation on tractor manufacture in 1956.

Mr. J. Buckman, General Works Manager of Standard's, speaking on the trouble they encountered, suggested that automation should be introduced gradually rather than attempt the change-over of a whole factory at one step.

The D.I.S.R. Report on Automation perhaps sums this up by saying :-

"One truth stands out from this report — the imperfections of present knowledge of the economic and social aspects of automation, when compared with knowledge of the technical possibilities."

impact on management

The recent report published by Political & Economic Planning, London (1957) on three case studies of automation in industry, brings out the increased importance of planning, when more automatic methods are considered, both for the introduction of new methods and for more detailed day to day guidance when automatic methods are used.

They do not, however, indicate that detailed and accurate forecasts of future requirements will be any more available to a firm installing automatic equipment than to other firms. Business forecasting is thus of increasing importance, while the need for more careful planning involves a higher proportion of management and supervision in the total labour force.

It is to be expected that there will be an increase in the technical complexity of production processes, with the result that management in general will require to have experience based on a wide technical background. This is borne out by the D.I.S.R. report on Automation (1956) which says :-

"Automation will demand a wider knowledge, greater ability and a higher degree of skill from worker and manager alike."

As already indicated, automatic production implies improvement in sales technique with a greater need for continuous market research, and the provision of objective statistical data.

Greater use will be made of accountants in assessing financial implications involved. In this connection,

Mr. A. J. Dumble recently pointed out, in a Paper to A.S.M.E., that realisation of the benefits resulting from mechanisation and automation will depend on the development and application of more detailed accounting procedures than are now commonly employed. The application of preventative maintenance rather than repair will become increasingly important, and the control of quality in manufacture will be effected by continuous control during manufacture rather than inspection after manufacture.

In a report, "Quality — Its Creation and Control," published in July, 1958 by the Institution of Production Engineers, an investigating committee under the chairmanship of R. K. Grunau, Chief Inspector, Rolls-Royce Oil Engine Division, proposes that "quality should be obtained by Operator Control, which can be achieved by the encouragement or re-creation of pride in workmanship. Quality should be induced from the Design Office onwards and it follows that the prime mover in this matter will be senior management".

In brief, managers, technicians, supervisors, operators and maintenance men, will become a team working together to obtain the best possible results from automated installations.

problems of introduction

Speaking at a debate on automation in the House of Lords in 1956, Lord Hailsham said: "There is no reason why the consequences of automatic machinery could not be forecast long enough ahead for the individual to make his plans about the recruitment and training of his labour force, and discuss well in advance with the representatives of the workers concerned how they will be affected".

Re-training will be an important problem for management and its importance is emphasised by the existing shortage of technicians and technologists, operators and maintenance men experienced in handling automatic plant.

However, even if this shortage did not exist, the Earl of Halsbury, speaking on this subject, points out that, from the psychological point of view, if a man's occupation is transformed by a machine, he should be given the chance to work the machine if he can. Halsbury recognises the danger of industrial society becoming divided into two hostile sub-groups — a managerial group relatively free and a workers' group relatively bound.

The three case studies in automation, mentioned earlier, emphasise that re-training has been necessary, but the evidence shows that for most of the operating staff this has not presented a serious problem. Workers with the new maintenance skills have not been easy to get, but much effort is now being spent in that direction. In regard to this, Pierre Bezier, Chief Mechanical Engineer of the Renault Company, in an article which was published in 1954, points out that for a long time it was considered that the personnel operating expensive and complicated machines ought to be provided with an extensive technical training, and that it would be necessary to envisage a high proportion of supervision and maintenance personnel.

These two fears have shown to be without foundation and seven-and-a-half years' experience enables him to state that the proportion of indirect personnel is smaller in the "4CV" (automated) department than in any other.

Another important point will be the question of *standardisation* and *simplification* as a *production factor*.

In conventional methods of production, the manufacturing methods are usually considered from the point of view of making the component to its original design. In the future, much thought will have to be given to the simplification and standardisation of components and processes, making them suitable for methods of production which require a minimum of human intervention. A great deal of research and development will be required to achieve that and management will have the problem of organising teams of specialists for this purpose.

effect on industrial relations

Ford Motor Company executive :

"How are you going to collect union dues from these machines?"

Walter Reuther :

"How are you going to get them to buy Fords?"

From the opinions expressed by trade union leaders, it is obvious that they are aware of the problems they can expect from the introduction of automation.

Mr. Edwin Fletcher, of the T.U.C. Production Department, in a Paper discussing how the trades unions will react to automation, said :-

"British Trades Unions have not opposed development of automatic production and control. Indeed, there is evidence of welcome from trade unions — there are few industries in this country in which unions have not experienced directly or indirectly some form of automation and unions know by experience that this way productivity is increased."

He goes on to say :

"This is not likely to be retarded by trade union action directed against developments themselves, but there will be considerable friction unless the trades unions are given full and early information of impending changes, and unless both managements and unions give serious consideration to the problems of the individuals affected."

It is interesting to note that there is at least one case of a trade union adopting automation.

The National Headquarters of the American International Association of Machinists have a data handling system processing the records of more than 900,000 members. This is said to have reduced work at a local level by 70% and central staff from 148 to 96 employees.

redundancy

The effect of automation on the level of employment, and the fear of redundancy, are matters which very much concern the worker employed in industries likely to be automated and it will require much more attention by the managements concerned in the future. For instance, it has been suggested that if the American motor car industry was fully automated, the production now obtained with over one million workers could be achieved with a labour force of only 200,000.

Now although this contingency is very much in the distant future and we have the D.I.S.R. report on Automation assuring us that :-

"So far as individual firms are concerned, automation has rarely caused workers to be dismissed, because it has affected large firms who can often transfer to other departments or adjust the rate of replacement of natural wastage" ;

nevertheless, we have the example of the difficulties which Standard Motors experienced in 1956, when they were unfortunate enough to introduce an automated plant at the same time as the Government instituted a "credit squeeze". They were, of course, unable to anticipate this happening when they started planning three years before, but Mr. Buckman, General Works Manager, admits that they failed to foresee the line of action which was taken by the workers' representatives, whose slogan was "No redundancy in any circumstances". Mr. Buckman points out that they had planned to overcome this by :-

- (a) restricting the intake of labour and reduction of overtime many months in advance;
- (b) drafting as much labour as possible on to other work during the change-over period;
- (c) using skilled production workers on the installation of new plant and laying off the remainder temporarily until production on the new work was accelerated.

Standards' have been criticised by the unions who maintain that they were consulted at too late a stage.

In general, the trades unions are adopting the attitude that redundancy and re-training are very much the responsibility of industry and Mr. Reuther, of the American U.A.W. - C.I.O. says that "It is just as reasonable to expect the employer to pay the cost of re-training, including the payment of wages during the re-training period, as it is that he should pay the cost of building the new plant or installing the new equipment."

Management will have to consider how to solve problems arising from changes in the economy of the country by means other than the "hiring and firing" of labour and changes in the volume of business may have to be taken up by profits, with a change in ideas about the period over which profits should be reckoned.

Mr. W. J. Carron, President of the A.E.U., speaking at a conference on industry and the nation, had this to say:-

"We have to accept that it is going to be a continuing necessity — in fact, a compulsion — to have an even greater integration of the three partners in industry — employers, trades unions and the State — until some particular point in time arrives when there are only two partners — the State and the Trades Unions." He doesn't see this happening for a long time but continues: "In the interim period — there must be a continuing concern by the Government for industry."

It would appear that unless management concern themselves with these problems outlined, they may find that they are subjected to increasing interference by the Government with a possibility of state control in the future.

Balancing this, on the credit side, Dr. A. King, Deputy Director, European Productivity Agency, speaking at a Management Conference, said that since the end of the War 50% of industrial growth has been in the form of products not manufactured at all at the outset, and in the next six years 80% of industrial growth is expected to be in the form of products not yet manufactured.

The problem of redundancy resulting from automation will be aggravated by any general decrease in the level of employment, and in Scotland with 10% of Britain's labour force, we at present have 20% of the unemployment, although industry has not been subject to automation to any great extent.

It may be difficult to avoid redundancy completely, but a great deal can be done to mitigate its effects.

changes in trades unions structure and labour force composition

It is obvious that one consequence of automation will be a change in the relative numbers of skilled, semi-skilled and unskilled workers. A number of new skills will appear and many older skills will become obsolete, so that many of the problems of demarcation which now exist will disappear.

If re-training is accepted as a feature of automation, then trades unions will need to reconsider their principles, which only admit as craftsmen those who have gone through the standard apprenticeship. It will be necessary for them to establish a standard for accepting workers of mature age, who acquire new skills through re-training.

As the number of technicians employed increases, one can foresee a change in size and strength of the trades unions and associations already existing for the protection of the technical and scientific worker, and an attempt on the part of the big unions now representing manual workers to open their ranks to the new and higher skills.

wage structure

Mr. J. A. Hunt, General Manager of The Hymatic Engineering Co., writes "It is likely that in the

automated factory the labour force will be more stable and have greater jobs security than at present. We may also abolish piece work and finally resolve the uneasy marriage of the ratefixer and the operator by the elimination of the first and the canonisation of the second".

The highly complex automatic factory will be very vulnerable to strikes and it is of the utmost importance that these should be avoided. One method might be the stabilisation of wages by accepting them as fixed costs in the same way as plant and other services are treated.

Existing ideas on piece work and incentive systems will need to be re-examined and increased importance will be placed on job evaluation.

Incentive schemes on a team basis are likely to prove more suitable to the efficient operation of automated plant. Time Study will still be used, but its importance will be accepted as a preliminary to machine and plant design.

Compensation for dismissal is another matter of growing importance, and the precedent having been established in this country by companies like Standard Motors and B.M.C., pressure for increased compensation is likely to continue and may open the way to a demand for a guaranteed annual wage.

Already, in America, agreement has been reached in at least one case, where workers subjected to "lay-off" are guaranteed 65% of their wages for 52 weeks, although this came about mainly in order to overcome hardship caused by the general practice of seasonal "lay-off".

shift work

It is generally agreed that the demand for shift work will increase and although the Trades Union Congress, through its Scientific Advisory Committee report, suggests that it is not opposed to shift work, it emphasises that there are many social problems involved in changing from day shift to multiple shift systems.

Shift work is made necessary by the fact that automation involves expensive capital equipment which, to be profitable, requires to operate as many hours a day as possible.

A major increase in shift work would necessitate inconvenience to the worker which may have to be met by increases in wages or decreases in working hours.

outlook for the future

Lacking the gifts of such eminent men as Albert Einstein, we are unable to look very far into the future, but he predicts that "Ultimate automation based upon atomic power will make our modern industry look as primitive and outdated as the Stone Age man looks to us now".

However, the future trend of certain industries can be seen in the developments which are now taking place in various countries.

While the general concept of industry, being made up of completely "automatic factories", is too far in the future to concern us, it has been reported that a machine at the Burroughs Computer Centre in

Philadelphia has carried out a real time analysis and control of a chemical process at the Du Pont, Niagara Falls plant, several hundred miles away.

This would suggest that, in theory, the stage of the automatic factory has been passed and progress is being made towards the automatic manufacturing organisation controlled from a central data processing system.

In the engineering industry one of the latest developments is a tape controlled transfer line now in use at the Hughes Aircraft Co., in America. Hitherto, transfer machining has relied on relatively large batch or continuous production for its economic application. In this latest development, which is a three-station transfer line, four different tapes can be used at once to make four different parts. This opens up tremendous possibilities for the economic application of transfer machining to most of the engineering industry.

Interesting developments are taking place also in the field of data processing. At Birkbeck College, London, a digital computer has been applied to the translating of languages, and reasonable translations from French to English have been achieved. An ideal translating machine would have, as part of its equipment, the ability to read from an original document and both the I.B.M. Corporation in America and Birkbeck College are working on this process at present.

Research is also being conducted into the possibility of a spoken word input operating a typewriter, *via* a computer, but this development is still very much in the future.

In America it is estimated that over 350 companies are developing numerical control systems and data processing and the U.S.A. Air Force has let about 20 million dollars' worth of contracts for development and production of numerically controlled tools and modification of equipment.

On the lighter side, but perhaps more disturbing, is the report that two Californian mathematicians

have programmed a computer to compose "American popular songs". One of the first compositions was given the title "Push Button Bertha". It is perhaps unfortunate that the designers estimate the machine could churn out 100 songs an hour and produce 1,000 million tunes without further instructions.

conclusion

Emphasis is placed on the need for careful planning and study in early stages and consultation with workers likely to be affected by the introduction of automation.

It is apparent that automation will produce many social problems, the solution to which lies in the application of good industrial relations, amounting in practice to a continuing sense of responsibility on the part of management, labour and Government for future developments.

The need for good industrial relations throughout industry was made apparent as far back at 1891 by Pope Leo XIII, in his encyclical "Rerum Novarum," on the condition of the working classes, when he said :-

"The great mistake made in regard to the matter now under consideration, is to take up with the notion that class is naturally hostile to class, and that the wealthy and the working men are intended by nature to live in mutual conflict. So irrational and false is this view that the direct contrary is the truth. Just as the symmetry of the human frame is the result of the suitable arrangement of the different parts of the body, so in a State is it ordained by nature that these two classes should dwell in harmony and agreement, so as to maintain the balance of the body politic. Each needs the other: Capital cannot do without Labour, nor Labour without Capital. Mutual agreement results in the beauty of good order; while perpetual conflict necessarily produces confusion and savage barbarity."

THE ILLUMINATING ENGINEERING SOCIETY

As part of its Golden Jubilee celebrations, The Illuminating Engineering Society has arranged a special series of lectures to be given in October, 1959.

There will be four lectures:

October 15 — "The Nature of Light" by Sir Lawrence Bragg, F.R.S., at The Royal Institution, Albemarle Street, London, W.1.

October 20 — "The Generation of Light" by Mr. L. J. Davies, at The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

October 22 — "Light and Road Safety" by Dr. W. H. Glanville, F.R.S., at The Institution of Civil Engineers, Great George Street, S.W.1.

October 27 — "Light and Productivity" by Mr. A. N. Irens, at The Federation of British Industries, Tothill Street, London, S.W.1.

Admission to these lectures is open to members of The Institution of Production Engineers, but is by ticket only, which may be obtained on application to:

THE SECRETARY, THE ILLUMINATING ENGINEERING SOCIETY,
32 VICTORIA STREET, LONDON, S.W.1.

A NEW INSTRUMENT FOR THREE-DIMENSIONAL INSPECTION

by A. G. JONES, M.Eng., M.I.Prod.E., M.I.Mech.E.

Aeronautical Research Laboratories,

Department of Supply,

Commonwealth of Australia.

BEFORE the manufacture of models for the high speed wind tunnels at the Aeronautical Research Laboratories, Melbourne, was commenced, an examination of the inspection techniques available led to the development of a new instrument for use with three-dimensional measuring machines. This instrument enables measurements to be made to an accuracy of .0001 in. or better, without any corrections, on to surfaces, curved or flat, without fatigue to the operator. As such, it represents an increase in accuracy to at least five times that obtained by the usual "small depth of focus" microscopes. It has been found to have wide applications in general engineering metrology problems, and has been in constant use for this work since 1956.

existing techniques

In general, measurement of wind tunnel models is carried out as described by Hill, on three-dimensional measuring machines, or on jig borers used as measuring machines. However, all such equipments depend ultimately on the "indicator" used to contact the actual surface being measured. This may be a "dial indicator" type of unit, involving a mechanical

stylus, or an optical device. The use of a mechanical stylus introduces several problems, including :

- (i) the force of the mechanical contact may deflect the model, particularly if very thin sections have to be measured;
- (ii) the actual point of contact has to be calculated from the size of stylus and the surface slope;
- (iii) the error recorded must be corrected for the size of stylus.

The "optical stylus" usually used consists of a microscope of moderately high power and small depth of focus. This is used by judging when the surface being examined is "in focus". Here no mechanical contact takes place, and thus the objections to the mechanical stylus are overcome. However, experiments with this type of instrument revealed :

- (i) it was difficult to judge when a surface was "in focus"; the operator must be skilled in its use;
- (ii) operator fatigue was considerable and readings could not be repeated;
- (iii) there is a very small clearance from the microscope to the work — this is considered a disadvantage since damage can occur easily.

A second type of optical instrument has been described (Ref. 1). Basically this consists of a range finder in which the operator matches up minute scratches on the surface being examined through two lines of sight, which are brought together in a military type range finder and eyepiece. This was examined and discarded on a number of grounds (discussed in Ref. 2), the major one being the inability of the operator to recognise the two views being examined, and hence to match them.

★ ————— ★
This article has been contributed following the publication in the March, 1959, Journal of the Thesis, "Inspection Techniques Applied to the Metrology of Aerodynamic Models", by H. T. Hill, A.M.I.Prod.E.

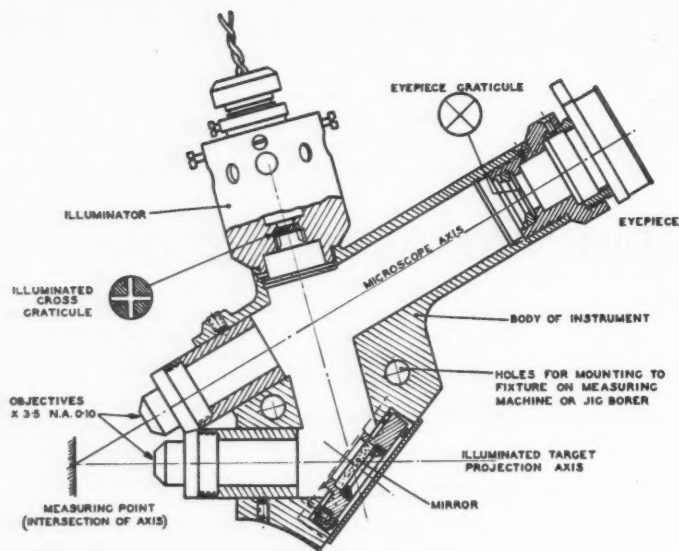


Fig. 1. Optical coincidence gauge.

the new instrument

The instrument subsequently developed (Ref. 2) is shown in Fig. 1. It consists essentially of a low-powered microscope, fitted with a cross graticule in its focal plane, and an illuminating system which projects a bright cross target image into the focal plane of the microscope objective. It is used on a jig

borer, mounted on the spindle quill with the axis of the illuminator objective horizontal and the microscope axis inclined upwards at 30° (Fig. 2).

The instrument acts as a type of range finder. It is so arranged that when a surface viewed through the microscope appears sharpest, the target cross image projected by the illuminator also appears sharp, and is centred on the fixed microscope graticule. As the distance from gauge to work surface is changed, a displacement of the target cross image occurs relative to the fixed microscope graticule. When coincidence is established by superimposing one cross upon the other, the gauge is at a fixed distance from the intersection of the axes of the illuminator and microscope, and it thus acts as a null indicator. Since the illuminated cross is at 45° to the microscope cross wires, the superimposing can be done with very high accuracy (Fig. 3) and little operator skill is required.

The actual position at which measurement takes place is the intersection of two "lines of sight". It is thus a discrete point in space, and no correction whatsoever has to be applied as in the case of any finite sized mechanical stylus. However, when measuring on to a surface which is inclined to the normal, distortion of the projected image occurs, and the measuring accuracy decreases slightly. A test to determine this accuracy consisted of taking a series of observations on to a flat surface inclined to the instrument normal at angles of up to 70° , observing the usual precautions for such a test. Thus the operator who set the measuring machine, using the coincidence gauge, was not in a position to see the scale readings obtained for each setting. At each angular setting, a series of five readings was taken. The results are shown in Fig. 4, where it will be seen that the total range of readings increases from 0.0001 in. when the viewed surface was normal to the gauge, to 0.0004 in. as the angle increased to 60° . However, if the worst reading out of the five was

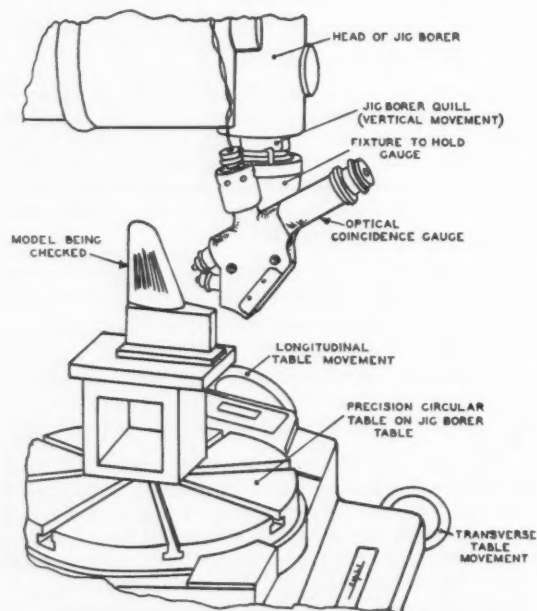


Fig. 2. Optical coincidence gauge mounted on jig borer — as used to examine the leading edge of a model tailplane.

neglected, then the total range of readings increased from 0.0001 in. at normal setting to only 0.0002 in. at the 60° setting, meaning that the actual position of the surface was observed to a maximum inaccuracy of ± 0.00005 in. at any angle within that range.

Similar results have been obtained when measuring on to spherical surfaces. This is a far higher accuracy than that claimed, as far as we are aware, for any other instrument of this type and application.

In addition to the accuracy possible, and normally and easily achieved, the instrument has many further advantages. Amongst these may be enumerated :

- (i) The actual point of measurement is denoted by the projected cross of light, which can be seen clearly by the naked eye. This enables one to know the exact "point of contact".
- (ii) The image of the projected light cross gives a measure of surface irregularities at the point being measured. In this respect the instrument operates as some forms of surface finish microscopes.
- (iii) Low power objectives are used, enabling the instrument to have a working clearance of the order of 1 in.

use of the instrument for model examination

For general model examination the model is set with its axis vertical on the jig borer table (Fig. 2). Vertical movement of the quill (and the coincidence gauge) and longitudinal movement of the table enable all points on the measuring grid, as defined by Hill, to be obtained. Transverse movements of the jig borer table move the model surface relative to the coincidence gauge and measurements are taken of the table position as coincidence is observed. By suitable pre-settings, absolute values of heights of profiles are readily obtained. Used in this way, a rate of

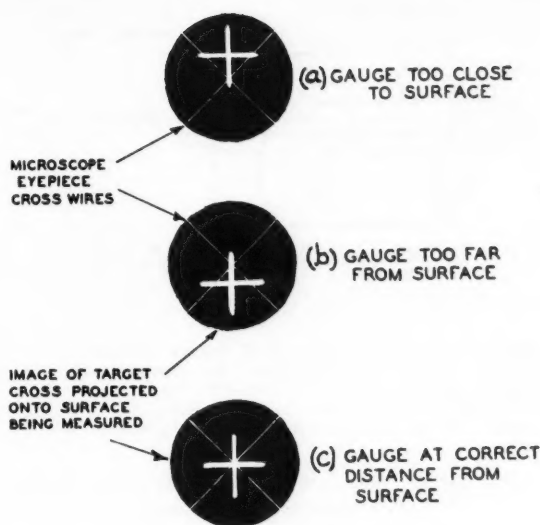
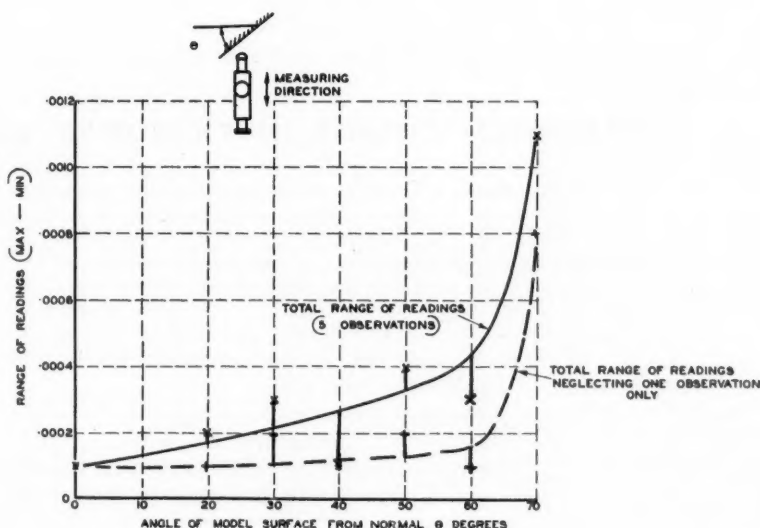


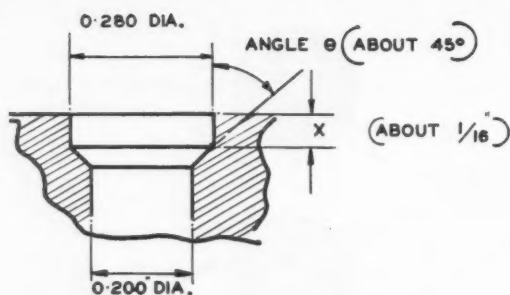
Fig. 3. View through eyepiece of optical coincidence gauge.

observations of 100 - 200 readings per hour is easily attained and maintained without loss of accuracy or operator fatigue.

Readings on a wing surface near the leading edge are taken up to the point where the wing slope is of the order of 60°. After measuring both upper and lower surface to this point, the wing is set up with the leading edge facing the coincidence gauge, and readings around the leading edge are taken again to a point some 60° away from the leading edge itself. Very small increments are used, frequently 0.001 in. The observations on upper and lower surfaces and the

Fig. 4. Check on repeatability of readings using optical coincidence gauge.





USING OPTICAL COINCIDENCE GAUGE, TAKING DEPTH TRAVERSES ACROSS TWO DIAMETERS, DIMENSION X WAS DETERMINED TO AN ACCURACY OF ± 0.00005 INCH AND ANGLE Θ TO AN ACCURACY OF $\pm 2\frac{1}{2}$ MIN.

Fig. 5. Typical "impossible" measurements, easily possible with optical coincidence gauge.

leading edge measurements are then plotted at a scale of 100 times full size. The overlap of 30° on each surface enables an accurate check of many of the readings and ensures that the final result will be to an accuracy of the order of 0.0001 in.

use of the instrument for general engineering metrology

Measurement of general engineering objects carried out using the coincidence gauge, during the last three years, are too numerous to detail. However, amongst cases which are noteworthy are those in which very frail items have had to be measured. These are merely placed on the jig borer table, without any clamping, and measured while supported in their natural state. A further example of interest is the

examination of inaccessible places. Thus, in Fig. 5 it was required to measure accurately the angle and position of a chamfer, of about 45° slope, some 0.06 in. down inside a bore of 0.28 in. maximum diameter. By taking depth traverses across two diameters, the distance to the beginning of the chamfer was determined to 0.0001 in., and the angle to within 2.5 minutes of angle (range of tangent of angle 0.0001 in. over 0.030 in. measuring length). This examination took approximately 15 minutes, including all necessary setting up, etc.

For the examination of two-dimensional shapes, such as templates, the instrument is used measuring on to the centre of the edge of the template. This has been found to reduce errors due to edge chamfer or burr, which can considerably affect readings by a normal jig borer microscope or by optical projector.

conclusion

The instrument described has been in constant use for some three years. During that time, used on a jig borer, it has largely superseded the conventional methods of measurement for many general engineering metrology problems.

acknowledgment

This Paper is published by permission of the Chief Scientist, Australian Defence Scientific Service, Department of Supply, Melbourne, Australia.

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SANDWICH COURSE IN EXECUTIVE DEVELOPMENT

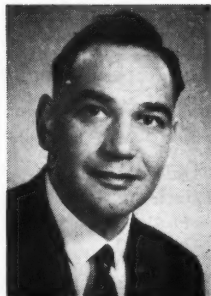
The Department of Commerce and Management of Sheffield College of Technology is to provide a Sandwich Course in Executive Development, commencing in November, 1959. The purpose is to provide for the young manager and potential manager a fully integrated plan of executive development, by bringing together in one scheme both education for management within the College, and general and vocational managerial experience in his working environment. Only students already engaged in industry and individually sponsored by their employers will be accepted into the course, which requires full-time attendance at the College for approximately 15 weeks during two academic years.

Further particulars may be obtained from :

THE ACTING HEAD,
THE DEPARTMENT OF COMMERCE AND MANAGEMENT,
1 MELBOURNE AVENUE, SHEFFIELD, 10.

THE TASK OF THE ENGINEER IN CENTRAL MANAGEMENT

by J. L. GWYTHHER, M.I.Prod.E.



Head of Department of
Mechanical and Production Engineering,
North Hertfordshire Technical College.

TO begin with I will qualify my title for this Paper. It is always useful to begin by defining one's terms and I feel some initial clearing up is necessary.

Let me start by considering someone who has been trained purely as an engineer; that term as used here covering chemist, physicist, or any technologist whose training was exact and related to specific things (tools, methods, facts,) being oriented towards science and the product rather than the management and commerce of its production and distribution. You will

recognise that the individual I have defined is not only a hypothetical character, but is in an embryonic stage of development with regard to a career in management. He still has a lot to learn, both theoretically and in the field of industrial experience. This margin—the gap between the aggregate of his capacity as a technologist, and the aggregate of his capacities as a senior manager or managing director at the age of 50+, is the gap which must be bridged by the engineer aspiring to a high position in central management.

We recognise at once that there is a margin between the newly trained engineer and the mature engineer-manager: but before proceeding, let us note that there is also a margin, and in my view a greater margin, between any other individual trained in the raw skills of his craft or profession, and the same individual perhaps 30 years later, in senior management. The value of this recognition lies in the fact that by examining the margin—the distance a man has to go—we can perhaps begin to distinguish a path and, marking it, make the way easier for young graduate engineers aspiring to high central management.

*a Paper presented to the Luton Section
of The Institution of Production Engineers,
14th October, 1958.*

basic qualifications of senior managers

Since we are going to concentrate on the margin, it is worthwhile considering what basic qualifications senior managers have. An invaluable survey carried out recently by the Acton Society Trust, the conclusions of which have been summarised by Miss Rosemary Stewart in the D.S.I.R. red book "Managers for Tomorrow", gives the answers. Miss Stewart says, "Only 19% of managers had a University degree, a third of them in arts; 18% were professionally qualified with or without a degree; and about 30% had a degree and/or a professional qualification. But the proportions varied from one firm to another . . ." "Needless to say, senior managers had more qualifications than the others; a third had degrees, and nearly as many were professionally qualified. The trend is for more staff to be qualified; it is especially marked with graduates. One in four aged 35-39 had a degree, but only one in 10 aged 55-59.

"Of the 18% that had professional qualifications, one-half were engineers, and more than half the rest were accountants or company secretaries. Yet slightly more senior managers were qualified as accountants or company secretaries than as engineers: this confirms the popular belief that accountants have a better chance of rising to the top."

The D.S.I.R. summary goes on to talk of the origins of managers. But leaving that topic aside—for all that it is important to our study—we might look for a minute at what has been said. In effect it is this—engineers and other scientifically trained types people the ranks of junior managers thickly, of middle managers less thickly and of senior managers much more sparsely. The accounting and secretarial types have moved up and gained, relatively, in the race. It is part of my task in this Paper to try to point out why this should be.

In passing I should also refer, however, to another group, the Arts graduates, who may also be brought into the comparison. These Arts graduates have not been professionally trained, and may belong to no professional association: their University tutors uphold that they have been "trained to think" and that therein lies their especial attribute. Be that as it may, they are to be found in key positions, especially in advisory, "staff" (as opposed to "line") and personnel functions. I suggest that their mere existence

at all in the complex of industrial organisation, though they join the race so late and would appear at first sight to be such foreign particles in the amalgam of people which makes an industrial organisation, is one essential clue to the data we seek.

the task of the engineer

In 1948, Professor Cave-Browne-Cave, in a Presidential address to the Engineering Section of the British Association, quoted Thomas Tredgold's definition of "engineering" as "the art of directing the great sources of power in nature to the use and convenience of man". Professor Cave-Browne-Cave rightly pointed out that this definition is so sweeping as to be hardly useful, and goes on himself to give a general description of the engineering task. He says it may include:

1. an accurate appreciation of the requirement;
2. the preparation of a plan and design to meet the requirement;
3. experiments and development work to extend existing knowledge to cover any special features;
4. the provision of the necessary material, equipment and personnel;
5. the process of construction or execution;
6. the examination and test of the finished work under extreme but realistic conditions, to ensure safety and fitness for the purpose and conditions specified.

Running through the whole process, he says, there are the cogent considerations of cost and efficiency.

I think the above is a comprehensive definition of the engineer's task; but before we continue let us just look for a moment at its several elements, and which officers in a factory deal with them in modern production.

1. "accurate appreciation of the requirement."
This is generally done by the Design Engineer in collaboration with the customer, unless the customer's requirement is so clear cut that he has already covered it with a tight specification.

Mr. Gwyther is a Member of Council of The Institution of Production Engineers, and the immediate Past Chairman of the Luton Section. He entered industry in 1938 as an apprentice with Messrs. H. W. Ward & Co. Ltd., Birmingham, where he was trained in Machine Shop Engineering.

In 1943, he joined the Aston Technical College, Birmingham, as an assistant lecturer, and served there until 1949, when he left to take up a senior teaching appointment at the College of Technology, Birmingham. He was appointed to this present post in 1952.

2. "the preparation of a plan and design . . ." The designing is done in the design department, in collaboration with the development and/or experimental sections. The production planning engineer should be consulted at this stage to add his advice.
3. "experiments and development work . . ." are carried out by the personnel in (2) above.
4. "the provision of the necessary material, equipment and personnel" embraces the whole factory! Purchasing, stores, manufacturing and personnel sides.
5. "the process of construction or execution" again embraces the manufacturing facilities of the factory.
6. "examination and test of the finished work . . ." covers the test section.

It is obvious that the engineer's task as outlined above can only be carried out by a great many workmen, supervised by chargehands, foremen, junior and middle superintendents and managers. It is these people I want to distinguish from the main burden of my theme. I want to leave them out of the discussion. For they obviously must be specialists — functionally expert in their own fields and having expertise absolutely necessary to those tasks. You will note that I have not referred to any shortcomings of the Engineering Manager: only engineers can do engineering in a competent way. I am talking about the Engineer-Manager *qua* Manager — the individual who has come up through the engineering functions and is now in general management — either as a General Manager or as an organ of a Board of Directors where he must advise and criticise over a wide range of functions in which he may not himself be expert. He will, of course, retain his specialist knowledge — it may be in virtue of that that he was appointed to the Board. But if we can use a platonic analogy and liken the industrial enterprise to an individual having within himself the three graces of wisdom, courage and virtue — in this context virtue means fitness for the task in hand, or overall efficiency; courage the enterprise of the sales force and officers of executive grades within the company, as a result of whose activities so much is thrown up for the consideration and approval of the Board; and wisdom the essence of all the talents and experience of the governing body of the company, which in practice is the Board of Directors. Exercise of this wisdom is the unique prerogative of the top manager in his participation on the Board of Directors: if he possesses only technical skills, he may reach the top technically, and should receive adequate recognition. But his value as a member of the Board of Directors will be not so great as if his background were wider. It is my thesis that herein lies the reason why otherwise successful engineers are not always appointed to the Boards of their companies.

functions of a board of directors

Before we proceed to consider how the otherwise successful engineer might widen his vision so that

he can effectively argue with other directors over matters of broad policy, it is worth looking at the functions of a Board of Directors, as they have been distinguished by one author. According to Sargent Florence the functions of top management are as follows (I quote): "Lightened by delegation, the 'core' load at the top level of industrial government consists of final decision on policy about:

- (a) what and how much to produce;
- (b) at what price and what investment; and
- (c) of decision on internal organisation, particularly
 - (i) the creation of new posts;
 - (ii) appointment to upper posts;
 - (iii) top supervision and co-ordination".

It is worth looking at these functions in detail, to see how they match up to the skills possessed by the individual whom I have called the "raw" technologist.

the product decision

Decisions about *what* to produce *can* be advised on by the technologist insofar as they concern a particular task and the efficiency with which the particular article must perform it. This will apply particularly wherever the article being produced falls within the functional or "tool" range of articles. Historians have distinguished a key point in the evolution of man as the point which separates him from the beasts: that point at which he began to use tools to effect his purposes. It is surprising how many of the things we make today are in that range of product: washing powders, soaps and detergents to get things clean; vacuum cleaners, refrigerators, and all vehicles; even houses and their heating systems can be considered from the technical aspects of economy in upkeep and running, and a comparative scale of values derived for the accessories which bring the comfort. Indeed, seeing that Boards of companies working in these fields do not usually include an artist or aesthete whose sole function is to advise on appearances, it is quite likely that the utility-through-technical-efficiency aspect will be the main one, and this is the technologist's own field.

the quantity decision

"How much?" is a question best answered by the market research people: but the engineer members of the Board of Directors should be able to comment upon the statistics they produce, and criticise their suggestions in an informed way. The market research people will have their price-demand diagrams to prove their arguments for or against the policy: but, except in cases where monopoly exists, these diagrams can only refer to a position where other products, wholly or partly substitutable for the firm's products, do not vary considerably in their pattern or proportion of supply. In an advancing technological age cross-elasticities of demand, which deal with the substitution effect, and income elasticities of demand, which deal with the greater demand arising from

a higher income to the consumer, are possibly more important in the short run than the price-demand effect, and in the long run inflation and increased labour charges may make nonsense of arguments based on present costs of supply. At the moment we are seeing the enormous effect of income elasticity of demand in the motor trade. Hire purchase facilities are allowed by the Government to induce a consumer boom. Overnight, it seems, the roads become crowded with cars. I think when statisticians evaluate the effect, they will find that demand increased first from the marginal consumer, who can now just about afford to run a cheap second-hand car, then from established motorists, disenchanted with the cars they already have, wanting new ones, probably in the same quality range. It is difficult to see how this chain-reaction can affect the demand for the better types of new car, however, for the customers for these have always been comparatively wealthy. Unless, of course, greater ease of disposal of their cars induces these customers to change more frequently.

price and investment decisions

Price again is a matter for market research and the sales force. But the argument above has shown how tentative their estimates must be. All members of the Board, including the technologist, should be ready to voice healthy suspicions, and indeed will strengthen the sales peoples' hand by doing so, for it will give them room for manoeuvre and formulation of joint policy.

Investment is the technologist's own field. He should be able to argue at Board level for the equipment, including renewals of outworn machines, which he knows will be necessary for the task. His critics here will be the financial men on the Board, who will argue from two points of view: (a) cannot the job be done with cheaper or existing machines, plant and personnel, and (b) if the investment is so heavy that the return will be small on a ratio basis, why do the job at all, why not make some other product or reinvest in some other business? I should explain that reinvestment is possible on a long term basis even in a business where fixed plant has high capital value, and is unique in application. Allowance for depreciation of this plant is merely used to set up another business. Thus mines and railways can, conceivably, be progenitors of light industries. This "why go on?" argument is the hardest argument to answer, and is only resolved in many businesses today by denying its validity altogether, and putting loyalty to employees, pride in product, or other non-financial consideration first.

internal organisation

Decisions on internal organisation are anybody's to comment upon. For example, theses have been written which variously limit the span of control of each officer to between five and 11 sub-officers, who each have policy decisions of their own to make: on whether organisation should be functional, line, or line and staff, on how the activities of specialist

lines should be co-ordinated: and on how "staff" functionaries can be brought into the authority chain and given some degree of product responsibility. Indeed, anyone who has followed the recommendations made by the various committees investigating the nationalised industries, and on replies given in Government White Papers, and subsequent action, will realise there is no degree of unanimity on these things and no one obvious "best" course.

But the technologist director should again be ready to argue in an informed way about the application of these principles, and policy in his own organisation, where the picture may be clearer to him than to anybody else, particularly on the factory side. His first-hand knowledge of the staff involved, of their abilities and authority relationships, should put him in a unique position to argue for a good, organic rather than mechanistic structure. In this context I should explain the term "authority" and refer to the excellent concept set out in Simon's book "Administrative Behaviour". Modern ideas of the authority relationship in industry refer to the relationship which exists between two people when one accepts the decisions of the other, without examining or questioning the premises on which these decisions were made. This concept, you will note, allows recognition not only of the authority of supervisors, as having a field of decision in which a part or all of a subordinate's activities lie, but of equals, who may have parallel adjacent fields of authority to each other.

Undoubtedly the most important modern implication of the concept, however, is in the fact that the authority of subordinates is acknowledged — that their discretion is reserved to them in certain of their activities, save when it is appealed against to the superior by some third party. Now, engineers have always "come through the mill" to some extent in gaining their professional qualifications: indeed, I often think that the period of practical work on the shop floor which our Institutions require as part of their basic qualifications for membership is valuable not only for the practical work done there, but also for the knowledge of the authority relationships which stems from being in that position! It stands to reason that the engineer-trained manager, understanding as he should these organic authority relationships in the factory better than anyone else, should be a key figure in arguing the proposed structure of a business enterprise — at any rate on the manufacturing side.

other considerations

I think I have said enough to indicate the main lines of my thesis. Other specific skills which the technologist has not met on his way up — such as cost accountancy, market research, and the theoretical aspects of the personnel side, should all be of interest to the engineer aspiring to the Board of Directors: but he should remember that rather than expert knowledge it is intelligent criticism of these — the "asking of discerning questions" as Gordon has put it — that will be his important contribution to

the overall supervisory, as opposed to specialist co-ordinative, functions of the Board. It is in connection with this faculty — the faculty of critical appraisal, that I will make my last remarks.

the skill of the critic

Let me go back 2,500 years — to the Greek philosopher Aristotle. Aristotle's method, developed in the days before exact measurement, was to classify, compare, and conclude. This method has been assailed by its critics — who may broadly be said to include those who have developed modern science since the 15th and 16th centuries; the grounds of their criticism are that it is inexact. What engineer has not heard quoted Kelvin's remarks about being able to measure a thing exactly, and to express in numbers the magnitude measured? If I remember correctly Kelvin concluded: "then you know what you are talking about". I quite agree that that is the method of modern science — the observation, measurement, and appraisal against some exact numerical quantitative scale of the phenomenon in question. Whitehead was quite right when he said that Aristotle's method had set science back 2,000 years.

the administrative man

But, if science prospered, was it at the expense of the critical method? It is my belief that it was. The method of classification and comparison of ideas and methods or contingencies non-quantitative or only semi-quantitative in character, was surely the method of Aristotle. It is also the method of the critic — the expert administrative man. We live in a world which becomes increasingly organised and administered — for better or for worse — from day to day. As our industrial output increases and the things we need to raise the standard of living of the world's peoples are more intensively produced, so is the need for more organisation and administration increased.

I do not know how many present at this meeting have read Parkinson's recent book. To my mind, the amazing thing about the book was not what it revealed, or even what it contained. The outstanding

thing was the amount of comment it aroused, and the interest it attracted. A book on the organisation of administration, you would think, would have little interest for the man in the street. But the 20th century man is not only a scientific man, he is an administrative man (at any rate in advanced countries of the Western hemisphere).

This argument would explain one dilemma which faces educationalists today. The question is, how to liberalise education? The need is there: industry, the Universities, both agree there is need for liberal education. The Ministry of Education have issued a memorandum saying how necessary liberal education is. But always, in the attempt to introduce it, the questions how to proceed and what to include have been major points of controversy. My own belief is that the real need of industry is an Aristotelian crown of the critical method upon the head and shoulders of the scientific method at present inculcated into engineers and technologists. That should bring more engineers into general management: and if all engineers cannot rise to be General Managers, then surely we could still do with a widening of vision at all levels, so that engineers become aware of themselves and their task in a comparative, more objective sense, and realise that there is not always only one answer to any problem.

acknowledgments

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"The Logic of British and American Industry", Sargent Florence. Published by Routledge and Kegan Paul.

"Managers For Tomorrow", Rosemary Stewart. Published by D.S.I.R.

"Administrative Behaviour", Simon. Published by MacMillan of New York.

"Parkinson's Law," or "The Pursuit of Progress", Parkinson. Published by Murray and Co.

"The Young Engineer", Paper by Professor Cave-Browne-Cave to the British Association, 1948.

JOURNAL BINDERS

The increased size of the Journal has made impractical the present type of binder, and as a result of requests from members, the Institution is now able to supply the "Easibind" type of binder, in which metal rods and wires hold the issues in place, and which is designed to hold six Journals.

It will be found that copies of the Journal can be quickly and simply inserted into this binder, without damage to the pages, and that binding six issues at a time, instead of twelve, will facilitate easier reference, and handling of the volumes.

The new binders may be obtained from: The Publications Department, 10 Chesterfield Street, Mayfair, London, W.1, price 10/6 each, including postage. Date transfers, for application to the spine of the binder, can be supplied if required, price 6d. each.

"COMMUNICATION OF IDEAS IN PRODUCTION ENGINEERING — ITS IMPORTANCE AND IMPROVEMENT"

Report of the North Midlands Regional Conference,

held at Nottingham, 6th June, 1959

THE proceedings were opened by the Regional Chairman, Mr. L. Shenton, who welcomed the Lord Mayor and Lady Mayoress of Nottingham, the Sheriff and Mrs. Hill and the Chairman of Beeston and Stapleford Urban District Council and Mrs. Plowman.

The Lord Mayor in his reply thanked the Chairman of Beeston and Stapleford Urban District Council for allowing him to extend a welcome to the delegates. He hoped that the Conference would be a success and that the visitors would enjoy the short time they were spending in the district.

After the Civic Party had departed, more than 100 delegates and their ladies paid visits to The Nottingham and District Technical College Engineering and Textile Departments, Royal Ordnance Factory and the Hosiery and Allied Trades Research Association.

After lunch, at which the Civic Party were again present, the Plenary Sessions were opened. The theme for the Conference was "Communication of Ideas in Production Engineering, its Importance and Improvement".

Mr. R. M. Evans, M.I.Prod.E., of Leicester, Chairman of the first Session, introduced the first speaker, **Mr. E. Moonman**, *Head of Human Relations Department, British Institute of Management*, whose subject was "The View of the Expert".

Mr. Moonman's first point was that almost all industrial difficulties arise through lack of communication. He stressed the need for the management to ensure an adequate knowledge of company policies, clear thinking about them and their explanation in a simple, straightforward manner. Wrong

impressions were frequently given by bad presentation of information. He said that one should try to see the nature of the problem and if managements were unable to express themselves clearly in report writing, etc., then some form of training should be undertaken before promotion. He commented that many executives for one reason or another were hesitant to commit themselves, either verbally or in writing, on what constituted company policy on matters of human relations activities.

As regards changes within an organisation, Mr. Moonman said that anyone affected by a particular decision should be brought in as early as possible — for example, on the introduction of a new machine. The position should be fully explained, otherwise ill-feeling was certain to result. The rules by which work was conducted must be formulated on the basis that they apply to individuals and not types. He quoted a recent experiment which showed a considerable and reliable increase in production when the workers were kept well-informed.

Mr. Moonman dealt next with communication within the company, concerning the capacity of one group to relate its feelings and ideas to another group. Joint consultation was very necessary, but only by a sincere approach would it be successful. The full facts concerning pension schemes, recruitment, redundancy, etc., must be given, otherwise trouble-makers could do untold damage. He quoted one instance where a foreman gave wrong information about redundancy, the company concerned having released no details by the official channels. Information circulated *via* the "grape-vine" should be guarded against. If details of pension schemes and

balance sheets were presented in a simple style instead of the usual legal one, there would be less ill-feeling amongst the work people. All information relating to bonus payments, the company's financial position, etc., should be posted on notice boards and included in works magazines. By doing this the co-operation of the work people would be obtained, as the management would have their confidence. The first responsibility for the release of information was with management and the passing of information should be part of the overall policy.

A general discussion then followed. **Mr. Simpson** of Peterborough, thought that communication must be upward as well as downward. The works management needed information from the shop floor and *vice versa*.

Mr. Moonman agreed with this, but suggested that items should first be dealt with by the foreman or shop stewards.

Mr. J. Lowther, Derby and District, pointed out the danger of employees learning about company profits from newspapers, and suggested that details of expenditure be given, with an explanation of the allocation of profits.

Mr. Moonman agreed that the responsibility was with the company to give these details, but not in legal jargon. He suggested the use of diagrams and charts showing costs, running costs, etc. If nothing was done, the employees would turn to newspapers and obtain the wrong impression.

Mr. Digby, of PERA, suggested a reluctance on the part of the workers to adopt new techniques and that films and lectures would help to explain the need for such changes.

Mr. Moonman agreed that this difficulty existed, but said that fears and suspicions could be dispelled with the aid of the joint consultative machinery.

The **Chairman** then brought the discussion to a close, commenting that there was a great deal of misunderstanding and wastage caused through poor expression and badly worded communications and that there was plenty of room for improvement. He mentioned that one of the qualifications for membership of The Institution of Production Engineers was that the candidate should have a suitable qualification in English. Any production engineer who cannot express views and ideas clearly is failing from the start.

The second lecture was given by **Mr. R. Ratcliffe**, C.B., M.B.E., M.I.Prod.E., *Deputy Controller of Royal Ordnance Factories, Ministry of Supply*.

Mr. Ratcliffe took as his subject "The View of Management and Administration". He said that management was one of the toughest jobs today; it was difficult, exacting and worrying, with so many changes and unforeseen things. Goods had to be produced at the right time, rate, quality and price. As regarded the product, the most significant thing was the change and rapidity of developments, thus making



This photograph taken at the Conference includes (left to right): Mrs. C. H. Hodgkins, wife of the Regional Treasurer; Mrs. J. W. Plowman; Councillor J. W. Plowman, J.P., Chairman of the Beeston and Stapleford Urban District Council; Mr. L. Shenton, Regional Chairman (rear); The Rt. Worshipful the Lord Mayor of Nottingham, Councillor J. Kenyon, J.P.; Dr. J. H. Mitchell, F.Inst.P., M.I.E.E., Research Director, Ericsson Telephones Ltd.; Mrs. B. A. Green, wife of the Nottingham Section Chairman (rear); The Lady Mayoress of Nottingham; The Sheriff of Nottingham, Alderman S. P. Hill; Mrs. Hill; Mrs. L. Shenton; and Mr. R. Ratcliffe, C.B., M.B.E., M.I.Prod.E., Deputy Controller, Royal Ordnance Factories, Ministry of Supply.

(By courtesy of the Nottingham Guardian Journal.)

them more and more complex. Standards of performance and finish were higher—products must be more attractive to fit in with changes and new environments. The introduction of electronics had given a new order of precision in detection and measurement and a very high standard of performance was required from machine tools through the wide range of production engineering. Standards were far higher than before the War, but the continuous search for new processes and better methods of working would help to keep costs down. There must be a constant drive to keep the product marketable and increase the demand for high quality in the world market.

Mr. Ratcliffe quoted the increasing use of machines for accounting, punched card systems, etc., and similar techniques using computers for the control of quality and for production control. This was being applied especially in refineries and chemical concerns, the chemical analyses being quick and accurate, with automatic corrective action when necessary.

Social changes were then dealt with. The Trades Unions are accepted and recognised as responsible and powerful influences in our national institutions, not only politically, but industrially. On the subject of disputes, **Mr. Ratcliffe** suggested that many trivial ones were caused by the lack of sufficient people of the right calibre within the Trade Union movement; if that was the case, the position was serious. He emphasised the need for joint consultation, which he said was far more extensive now, mainly because the Trades Unions were accepted as both powerful and responsible bodies. Consultation was needed to ensure that the product when made did satisfy the customer's requirements.

In conclusion, Mr. Ratcliffe said that during recent years managements had had a perplexing job, which on the whole had been done very well, and we could be proud of the achievements in this country industrially. However, the future was just as exciting and we could look forward with confidence. The humanity angle needed careful handling, but its improvement would do much to bring the desired security to everyone.

The subject was at this point thrown open for general discussion and **Mr. Swinfield**, of Leicester, quoted an example when a Joint Consultative Committee had not been adequate to deal with a dispute. When the committee failed to solve the problem, a news sheet was circulated to all employees at their home addresses. With pressure from home the dispute was finally settled.

Mr. Ratcliffe replied that he was not in favour of these "clever" methods. Communication must be through the channels set by the organisation pattern, from management to apprentice. The instance quoted by-passed the foremen completely.

Mr. Evans, of Leicester, agreed that joint consultation had its place, but pointed out that the foremen could still be by-passed. These committees were composed of representatives of the workers, usually Trade Union representatives, and higher level members of the management. He suggested that the management could often deal with minor problems through the foremen, instead of calling regular committee meetings.

Mr. Ratcliffe suggested that foremen should be represented in joint consultation, but that it rather depended on the size of the organisation and its nature.

Mr. H. W. Bowen, O.B.E., *Chairman of Council of the Institution*, was in favour of foremen being brought into the meetings on points in which they were directly concerned. Should the foremen be unable to attend, then the matter should be deferred until the next meeting.

Mr. L. Pitteway, of Leicester, asked that duties and responsibilities be clearly understood. Frequently there was difficulty in defining exactly what the duties were and who was responsible. Many problems arose with specialist staff; for example, planned maintenance and production requirements might be in conflict and there must be some recognised level where these troubles could be resolved.

The Chairman of this Session, **Mr. A. J. Clarke**, of Derby, then closed the discussion.

The final speaker was **Mr. Cyril Taylor**, *Divisional Organiser of the Amalgamated Engineering Union*, who took as his subject "The Trade Union View of their Liaison within the Industrial Structure".

He commenced by tracing the history of Trades Unions. They were first formed by workpeople for improving payment and conditions at a time when bitter relationships existed between workers and

employers. He then turned to statistics. There was now a Trade Union membership of 9,000,000 out of a total of 24,000,000 and the trend was now for fewer, but larger, Unions. In 1900 there were 1,300 Unions and in 1940 these had been reduced to 1,000. In the next 10 years the number dropped by a further 300, but during that time the membership was increased from 6,000,000 to 9,000,000 and the funds from £25,000,000 to £62,000,000. In his view although this was a powerful force, there were still too many Unions.

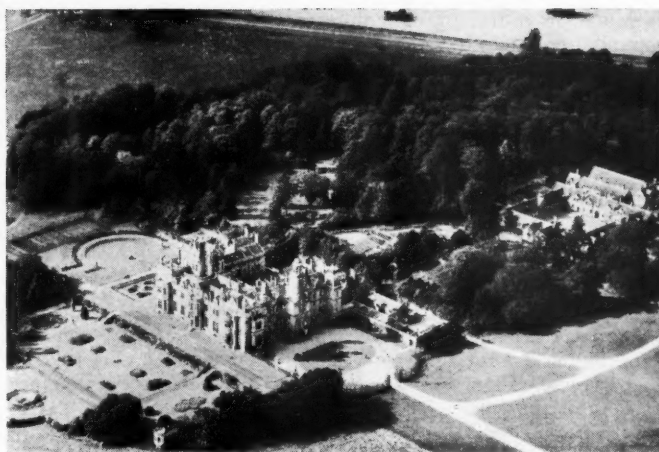
In 1920 official recognition was given to the Shop Stewards' Movement, which had been in existence in the previous century, though not recognised by any official body. The Engineering and Allied Employers National Federation recognised them and since that time the movement had performed a very useful job, especially as a link between management and shop floor. Unfortunately, their function and responsibilities were not always properly understood by the shop stewards themselves and often the men chosen were not the most level-headed, but those who had much to say for themselves; these were not necessarily the type of person the Union wanted.

Many Joint Consultative Committees were established during the War and the Government encouraged their formation. They proved very successful at that time, but they were unpopular with many firms. Only about one-tenth now remained, the rest having been considered an intrusion by the management and disbanded. Mr. Taylor said the Trades Unions were interested in production problems and to this end had arranged schools for their members, either of a week's duration or at week-ends, which had proved most beneficial. They realised that it was no use negotiating higher wages and better conditions, if the industry itself did not prosper. Their interest in problems and success of the industry made for continuity of employment for members and reasonable wages and conditions.

One major difficulty was the multiplicity of Trades Unions. In many cases a dispute was used to advance the interests of the Unions and frequently the real issue involved was lost in the struggle. Battles between Unions were regrettable and were mainly due to this multiplicity. Another cause of trouble was faulty negotiation. There was too much remoteness between top level management and the shop floor. Some managers were very antagonistic towards joint consultation and felt that only they should run the business, without assistance from the Trades Unions. They did not realise the dangers involved; rumours could then be spread by trouble-makers, and there was resistance to change by the workpeople. Changes created fears — of being transferred to another department, redundancy, etc. Regular employment was one of man's most fundamental needs today and uncertainty could unsettle the whole department or factory.

Mr. Taylor gave two examples of the approach to a problem — the first was a company whose management called a meeting with Trade Union and other representatives of the workpeople. With the aid of diagrams and charts it was explained that their

An aerial photograph of Thoresby Hall, which was visited during the Conference by the delegates' ladies.



finances were gradually diminishing and unless something was done, the position would become serious. Their remedy was to introduce work study. The managing director elaborated on this and asked if the shop stewards would select certain of their number to undergo appreciation courses, to enable them to understand more clearly and explain the position to the workpeople. This was done and work study was introduced and was still going on quite smoothly. A second company in precisely the same position had introduced work study without any explanation to the shop stewards, and Mr. Taylor had needed to make numerous visits to clear up the many troubles which had arisen.

Weekly meetings between top management and shop stewards could discuss labour problems, introduction of machinery, delivery dates, rate of production, etc. This was the best link the General Manager could have with the shop floor, but the foreman must not be left out—both shop stewards and foremen should be given information at the same time. Mr. Taylor recommended that the Foremen's Association be informed as well and that the minutes of meetings, which should be easily intelligible, be posted on notice boards. Changes could be introduced if the workpeople knew that the benefits would be shared by everyone concerned—customers, management and themselves.

In the subsequent discussion, **Mr. Freeman**, of Leicester, asked what the procedure should be for private companies. He asked whether the workpeople should be told unpalatable truths regarding the future of the company, or whether white lies were permissible.

Mr. Taylor replied that the truth should always be told, otherwise rumours would result. All such matters should be fully discussed between the management, foremen and shop stewards.

Mr. Digby, of PERA, asked whose responsibility it was to make decisions and **Mr. Taylor** said that

the final word should be that of the management. The Trades Unions and anyone else concerned should be consulted, but they could not give final decisions.

Concluding the discussion the Chairman of the Session, **Mr. L. P. Simpson**, M.I.Prod.E., of Peterborough, commented that a good shop steward was a valuable asset, but a bad one did untold damage.

The final Session was the summing-up by **Mr. J. R. Pollard**, M.A., A.M.I.E.E., M.I.R.E., of *Ericsson Telephones Ltd.*

Taking Mr. Moonman's lecture first, he commented that he spoke forcibly on what he thought the company's attitude should be, but much of this was perfection, and was not in operation at the moment. A high level of understanding between management and workpeople was very desirable, but whether it was realisable or not was not yet known. As regards the communication of policies and instructions, Mr. Pollard underlined the necessity for workers to be classed as individuals and not types, and deplored the use of such phrases as "Personnel will report to". He also agreed that decisions should be in writing, and advocated the use of diagrams and charts to explain in a simpler form, subjects such as finances, etc.

Turning to Mr. Ratcliffe's subject, Mr. Pollard commented first on changes caused by the introduction of electronic control systems, for example. He suggested that this was a subject which particularly needed adequate consultation and discussion. The man on the shop floor could envisage that he and his colleagues would be replaced by a fearsome box with knobs and a man in a white coat, this idea coming mainly from science fiction, books and magazines. In fact, there would be what amounted to a second industrial revolution, with, for example, punched tape control and work done by electronically controlled machines. There would be some

measure of re-training for different jobs and re-organisation might be necessary in some industries.

Commenting on Mr. Ratcliffe's remark that consultation was needed to make sure that the product, when made, did in fact satisfy the customer's needs, he said that British industry was often criticised for this. One example was that we exported cars to the U.S.A. with threads which did not fit American sizes, and so the whole industry got a bad name.

Mr. Evans had said that too much was referred to joint committees and Mr. Ratcliffe replied that care must be taken to avoid the foremen being by-passed and also suggested that they attended meetings. Mr. Pollard said he felt that this was possible for a small firm, but in a large one, with say 70-100 foremen, such representation would be impossible. If only six of each of the parties to be represented in a discussion were invited, then some 30 in all would be present and it would be possible for lobbying to produce decisions before the meeting; owing to the size, the formation of sub-committees would be the result. If there was to be a committee, it should be an effective one.

Mr. Pollard next turned to Mr. Taylor's lecture, complimenting him on a most valuable and enlightening account of the origin of joint consultation, particularly with reference to the circumstances in which it first arose. Mr. Taylor was critical of some aspects of joint consultation, and in support of the criticisms, Mr. Pollard quoted instances where the so-called joint production committee was little more than a body for dealing with such matters as bad time-keeping. On the subject of the multiplicity of Unions, Mr. Pollard felt that there was trouble even in the large Unions, possibly through bad shop stewards, and it was not necessarily a good thing for the smaller Unions to be taken over by the large ones—in this "tidying-up" process they could be lost in obscurity.

With regard to the responsibility for making decisions, Mr. Pollard asked how far was it fair and equitable for Trades Unions, shop stewards and foremen to be consulted and have their views taken into account, without them at the same time accepting some responsibility for the consequences.

It was not sufficient to say that the Unions must be consulted if, after consultation, management took a decision which perhaps turned out to be an unfortunate one and it alone had to take the consequences.

This concluded Mr. Pollard's Summary and the Chairman of the Session, **Mr. J. Cunningham**, M.I.Prod.E., of Lincoln, complimented him on his very clear and concise summing-up.

Mr. B. A. Green, Chairman of the Nottingham Section, before introducing **Mr. Bowen**, Chairman of the Council, said that he hoped the decisions of the North Midlands Region to hold a Conference on this subject would bear fruit in due course, by leading to better communication in production engineering.

Mr. Bowen then wound up the meeting. He expressed thanks to Ericsson Telephones Ltd. for the use of their facilities and said he was sure all would agree that it had been an excellent Conference. It was his duty to extend to all the speakers the appreciation of the delegates present. There had been amusing remarks, some wise and some with which one could not agree, but that was what a discussion was for. In conclusion he thanked the delegates for attending and was pleased to see so many keen members. He hoped the Conference would prove beneficial to all.

special arrangements for ladies

Whilst the Plenary Sessions were in progress the delegates' ladies paid a visit to Thoresby Hall, the picturesque home of the Countess Manvers where, after a delightful tour through the well-known Dukeries they were shown the many attractive apartments and heard the historic associations of the family's possession.

The Lace Federation of Great Britain staged a most interesting display portraying the history of lace, which proved of considerable interest and was greatly admired.

The afternoon was thoroughly enjoyed by all the ladies and their arrival back at the Conference venue was timed so that they could join their men folk for buffet tea.

PERA NEWSLETTER — concluded

are being taken to create equally effective lines of communication with Russia, Czechoslovakia, Poland and countries in the Far East. Close studies of production engineering research activities in Russia, Czechoslovakia and Poland were made by Dr. Galloway, the Research Manager and Information Manager when they visited these countries in May and June.

1959 series of five-day courses

A new series of Five-Day Courses began recently. Courses to be held this year will again deal with a very wide range of subjects including metal cutting, press working, automation, machine tools, cold extru-

sion, machinability, deep drawing, stretch forming, tool grinding, surface finish, precision casting, spark machining, etc. The main objective of the courses is to cut production costs by stimulating the practical application of PERA researches in industry.

Since Five-Day Courses were first held three years ago they have been attended by 1,200 key personnel from all levels in member-firms. Lecture theatres, demonstration facilities and accommodation have been greatly improved and enlarged, and further additions have recently been made to the demonstration equipment in order to increase the time devoted to practical demonstrations of important research results.



Quarterly Newsletter to the Institution

CONSIDERABLE interest has been aroused in industry by the publication of "Machines and Tooling", PERA's cover-to-cover translation of "Stanki i Instrument", one of Russia's leading production journals. The first regular issue of this monthly journal, which was distributed in April, contained reports on the following subjects:-

- Gear cutting with high feed rates
- Four-spindle head for milling four grooves simultaneously
- High-speed grinding
- Electro-spark machining
- Hydraulic drives for automatic lines
- Magnetic-flaw detection
- Increasing the productivity of multi-tool semi-automatics
- Balancing
- Determining the number of teeth for gear wheels in planetary mechanisms
- Quality control of conical hobs
- Machine fixtures
- Ejecting finished components from a centreless grinding machine
- Reconditioning lathe chucks
- Indicating device for accurate measurement of tool slide movement
- Reduction gear unit for machine tools
- Automation of horizontal milling machine

As vitally important research and development work is in progress in a number of research organisations and factories in Russia, Germany, Czechoslovakia, etc., the Association has recently greatly extended its facilities for translating all types of technical and scientific literature in a number of languages.

Arrangements have also recently been completed with the Department of Scientific and Industrial Research for the translation and publication of a second Russian technical journal, "Vestnik Mashinostroyeniya", under the title "Russian Engineering Journal". This publication will also be issued monthly from July onwards.

"Russian Engineering Journal" covers a much wider field of production than "Machines and Tooling", and also embraces many important aspects of mechanical engineering. Recent issues of the original Russian journal have dealt with methods of improving the wear characteristics of roller chains, the construction of Cermet blanking punches, the design of seals for hydraulic machines, precision finishing of holes by ball rolling, high frequency metallisation, progress in pressure casting processes, developments in automatic handling, development of forging shops, surface seizing of gear teeth, precision methods of straightening sheets, and the influence of cutting tools on the efficiency of automatic machining processes.

Since PERA was formed in 1946, the closest possible contact has been maintained with production engineering research organisations throughout the world, and particularly effective communications have been established with research workers in all parts of Europe, the U.S.A., the Commonwealth and Scandinavia. In consequence, there has been a continuous flow of information to PERA from research organisations and factories in those areas. The publication of cover-to-cover translations of Russian technical journals is one of a number of steps which

(concluded at foot of facing page)

An important feature of PERA's five-day intensive courses is the demonstration of improved production techniques developed by the Association.



"QUALITY IN INDUSTRY"

The "Quality in Industry" Conference, organised jointly by The Institution of Production Engineers, The Institution of Engineering Inspection and the British Productivity Council, and held at the Palace Hotel, Buxton, on 18th - 19th June last, attracted an attendance of 170 management delegates to hear nine Papers by authoritative speakers, and to take part in the subsequent open discussions. A report of the Conference is to be published and the Papers and discussions will also appear in subsequent issues of the Journal.

This photograph, taken at the closing session, shows Sir Frederick Wrisberg, K.C.B., C.B., M.I.E.I., President of The Institution of Engineering Inspection and Managing Director of Linotype & Machinery Ltd., delivering his address on "Quality and the Future". Mr. G. Ronald Pryor, President of The



Institution of Production Engineers and Chairman of the session, is seated (centre) with Mr. Basil H. Dyson, Chairman of the Conference Organising Committee.

SWANSEA SECTION SOCIAL EVENING

The Social Evening arranged by the Swansea Section at the Caswell Bay Hotel last May was a most successful occasion. The Social, which included a buffet and the showing of the film of the Fuchs' expedition, "Foothold on Antarctica", was attended by 62 members' ladies and friends, and included 22 invited members and ladies from the Cardiff Section.

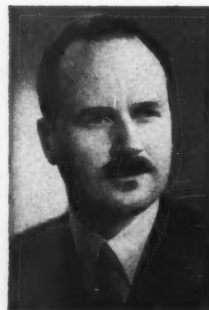
The Swansea Section was honoured by the attendance of Mr. W. F. S. Woodford, Secretary of the Institution, and Mrs. Woodford, who were welcomed by Mr. J. S. Hopkinson, Section Chairman. Mr. Woodford, in his response, spoke of the part production engineers can play in South Wales in the establishment and expansion of industry in the area.

Mr. H. G. H. Dixon, Chairman of the Welsh Region and of the Cardiff Section, proposed a vote of thanks to Mr. and Mrs. Woodford and to the Swansea Section.

This was the first function of its kind held since the formation of the Section in 1947.

CHAIRMAN OF NEW COMMITTEE

Dr. T. U. Matthew, Member, Engineering Director, Tube Investment Group Services Ltd., has been appointed Chairman of the Industrial Training Certification Committee set up earlier this year by the Birmingham College of Technology. The Committee is to advise and approve schemes of practical training for Dip.Tech. Sandwich Course students in Mechanical, Electrical and Production Engineering.



The Committee, which comprises a number of leading Birmingham industrialists, together with the heads of the College Departments concerned, is at present engaged in the preparation of some notes for the guidance of industrial companies already participating or about to enter students in the Sandwich Scheme.

PRESENTATION TO INSTITUTION PRINTER

At the meeting of the Finance and General Purposes Committee, held on 9th July, 1959, a bracket clock, suitably inscribed, was presented to Mr. C. Barker, Institution Printer, in appreciation and recognition of his 25 years' service with the Institution. This photograph shows Mr. H. W. Bowen, O.B.E., Chairman of Council, making the presentation to Mr. Barker. Others present were (from left): Mr. J. C. Z. Martin, Vice-Chairman, Papers Committee; Mr. B. E. Stokes, Chairman, Editorial Committee; Mr. S. Caselton, Deputy Secretary; Mr. W. F. S. Woodford, Secretary; Mr. R. H. S. Turner, Vice-Chairman of Council; Mr. R. E. Mills, Chairman, Standards Committee; Mr. E. Percy Edwards; Mr. G. Ronald Pryor, President of the Institution; and Mr. L. W. Bailey, Chairman, Hazleton Memorial Library Committee.



CANADIAN SECTION WORKS VISIT

It is reported by the Canadian Section of the Institution that their 1959 activities commenced with a tour of the Richard L. Hearne thermal generating station in Toronto, which belongs to the Ontario Hydro-Electric Power Commission. Plant engineers conducted groups of members throughout the station, the tour lasting approximately two-and-a-half hours.

The original plant opened in 1951, with an installed capacity of 400,000Kw, and is being enlarged to a capacity of 1,200,000Kw, when it will be the largest thermal generating station in the British Commonwealth. Members were interested to note, during the tour, that all the steam turbines, together with much of the auxiliary equipment, were manufactured in the United Kingdom.

MEMBERS TRAVELLING OUTSIDE THE UNITED KINGDOM

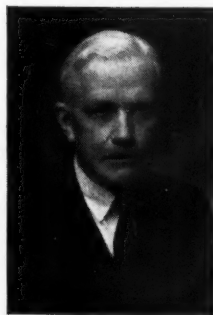
Members who are visiting Australia, New Zealand, India, South Africa or Canada, are reminded that the Institution has local Sections in these countries, where they will be made very welcome by the Institution's Honorary Officers and members there.

Papers on subjects of interest to production engineers and managers are always welcomed, and any members who are visiting one of the Sections outside the U.K., and who would like letters of introduction, should inform the Secretary of the Institution at 10 Chesterfield Street, Mayfair, London, W.1.

OBITUARY

The death of **Mr. A. T. Holman**, O.B.E., J.P., M.I.Mech.E., M.I.Prod.E., which occurred in Lisbon in June last, at the age of 67, is recorded with deep regret. His passing is a grievous loss not only to the Institution and the profession of production engineering in general, but in particular to the Cornwall Section, of which he was a founder member, and where he was so widely known and esteemed.

Mr. Holman, Chairman of Holman Bros Ltd., was the great-grandson of Nicholas Holman, who, in 1801, founded the engineering works near Camborne from which the world-renowned Holman business developed. Educated at Blundell's and Birmingham University, Mr. Holman served engineering apprenticeships with the family firm and Alfred Herbert Ltd., joining the Board of Holman Bros. in 1914. Following service with the Armed Forces during World War I, he returned to Camborne, to give special attention to the technical



development of the firm. He became Chairman on the death of his cousin, Mr. J. Leonard Holman, in 1949.

In addition to the vigorous and enthusiastic direction of his Company, Mr. Holman played a very prominent part in public affairs. He was at one time High Sheriff for Cornwall; Chairman of Governors

of Cornwall Technical College; Governor of the School of Metalliferous Mining, Cornwall; Founder of the Cornish Engines Preservation Society; Member of Council for the Preservation of Rural England; Chairman of the Trevithick Memorial Committee; and a member and former President of the Camborne & Falmouth Conservative Association. In these and many other spheres of activity, his advice and counsel were held in high regard.

A man of sterling quality, exceptional integrity and outstanding generosity, his example and influence will be sadly missed not only in the county to which he was so devoted, but also by all who were fortunate enough to come into contact with him.

The Institution also regrets to record the death, at the age of 74, of **Mr. W. F. Paul, J.P., M.I.Prod.E.**, of the Sydney Section. Mr. Paul, who was Chairman of the Board of Electric Control & Engineering Ltd., and a Director of W. G. Pickerells Ltd. and of Super Steel Ltd., settled in Australia, from Scotland, in 1906, and became a Member of the Institution in 1938.

During World War II, Mr. Paul, his wife and some local voluntary helpers, raised £7,000 for the Australian Comforts Fund, and in recent years aided many charities by screening colour films which he made himself. He will be long remembered in the Section as a man of unfailing good humour and kindness.

news of members

Mr. R. K. Allan, Member, has retired from the Luton Section Committee after 21 years' continuous service. Mr. Allan has been asked to continue to attend Section Committee meetings as he feels inclined, for his advice and counsel will always be welcomed. Mr. Allan also served for many years on the Institution's Standards Committee, of which he was a founder member.

Mr. P. E. Blackstone, Member, formerly Joint Managing Director, Production-Engineering Ltd., is now General Manager, Industrial & Commercial Finance Corporation Ltd.

Mr. G. L. Brough, Member, has relinquished his appointment as Architect and Technical Consultant with the Canadian Dredge & Dock Co. Ltd., Canada, and has now opened a practice at Kingston, Ontario, as Consultant on Marine Engineering and Naval Architecture.

Sir Stanley Harley, Member, Chairman of The Coventry Gauge and Tool Co. Ltd., has been elected Chairman of the West Midlands Union of Conservative and Unionist Associations.

Mr. A. G. Jones, Member, has been appointed Managing Director of Guy Motors Limited, Wolverhampton. Mr. Jones was formerly Director and General Manager of Broom & Wade Limited.

Mr. R. R. H. Marriott, Member, has now retired from the Ministry of Supply.

Mr. E. Alexander, Associate Member, is now Divisional Director and General Manager of A.E.I. Electronic Apparatus Division, Leicester.

Mr. G. F. Browne, Associate Member, has been granted the Insignia Award of the City and Guilds of London Institute.

Mr. L. W. Castle, Associate Member, has relinquished his position of Production Engineer with A.C. Delco, Division of General Motors, Dunstable, and has taken up an appointment with A.E.I. Hotpoint, Peterborough, as Senior Methods Development Engineer.

Mr. S. Jovanovitch, Associate Member, has taken up the appointment of Research Engineer with Rome Cable Corporation, Rome, New York, U.S.A.

Mr. L. B. Lockwood, Associate Member, is now Works Director of Thomas Crompton & Sons Ltd., Ashton-in-Makerfield.

Mr. K. E. Miles, Associate Member, is now a Lecturer in Production Engineering at The Loughborough College of Advanced Technology.

Mr. D. P. Basu, Associate, is at present on a Special Ford Foundation Travel and Study grant for Operational Research. Mr. Basu has been awarded this grant to enable him to observe the techniques of Operations Research as applied in United States business and Government organisations, and to participate in one or more Operational Research projects.

Mr. J. L. Townend, Associate, who has retired from office as Honorary Secretary of the Leeds Section, after 12 years, has been presented by the Section Committee with a wrist watch in appreciation of his services.

Mr. Alan Lowdon, Graduate, has relinquished his appointment with Charles Churchill & Co. Ltd., and is now Area Sales Manager (North of England and Scotland), with Taylor, Taylor & Hobson, Leicester.

Mr. George Kuruvila, Graduate, has relinquished his position of Graduate Mechanical Engineer with the British Transport Commission, and has now taken up an appointment as Development Engineer, Pumps Division, Siemens-Schuckert Elektromotorenwerk, Bad Neustadt/Saale, Bavaria.



Mr. R. Whitehead, Graduate, of the Manchester Graduate Section, has been awarded the Senior Chairman's Prize for the best Paper by a Graduate. The prize this year was presented by Mr. F. C. Cranmer.

CORRECTION

Mr. E. C. Wheeldon, C.B.E., Member, was incorrectly reported last month amongst the Birthday Honours as having received the M.B.E. The Institution is glad to take this opportunity of stating that Mr. Wheeldon was, in fact, awarded the C.B.E.

Hazleton Memorial Library

ADDITIONS

Members are reminded of the following Library rule, which is frequently ignored :

"The initial loan period is one month, and borrowers may keep books and periodicals for further periods of one month, if they ask the Librarian, and if no other borrower wants them. Applications for renewal may be made by post or telephone."

"Modern Engineering Workshop Practice." London, Odhams Press, 1959. 4 volumes. Illustrated. Diagrams. £9 5s. 0d.

A comprehensive manual of workshop practice for the student and apprentice. It is under the general editorship of Professor W. A. Tuplin, Professor of Applied Mechanics, University of Sheffield. Volume 1 deals with bench work, drawing and mathematics for engineers, materials and lathe practice. Volume 2 surveys welding, soldering and brazing, jigs and fixtures, tool making, machine tools, gear cutting and foundry work, and Volume 3, forging, heat treatment, sheet metal work, plating and surface treatments, power supply, plant installation, time and motion study and the factory regulations. Volume 4 is in the form of a wallet containing 44 tables and charts in four sections: engineering materials, cutting tools, gear cutting, welding, and general workshop data and tables (e.g., screw threads logarithms, physical constants). The contributors include Rolt Hammond, H. C. Town, Eric N. Simons, and Anne Shaw. The many detail photographs in the books are particularly clear, and combined with the accompanying diagrams, greatly add to the usefulness of the work.

Public Schools Appointments Bureau, London. **"Some Engineering, Scientific and Commercial Training Schemes."** 4th edition. London, the Bureau, 1958. 181 pages. (Bulletin No. 63a.)

A summary of information (mostly in tabular form) of training schemes provided by firms in the United Kingdom. Contents:- Student apprenticeships in engineering — Chemistry training schemes — Group apprenticeship (Engineering industries group apprenticeship and Scottish electrical training scheme) — Industry aided university courses — Commercial training.

Scott, J. A. **"Budgetary Control and Standard Costs: the Practice of Accountancy as an Aid to Management."** 4th edition. London, Pitman, 1958. 213 pages. 21s.

Contents: Introductory — Budgetary control — Preparation of the budget — Standard costs — Budget and cost reports and accounts — Advanced budgeting — Financial control — Action. *Appendices:* Costing methods — Analysis and machine accounting — Monthly accounts — The fixing of standard times and rates — Bibliography.

Chorafas, Dimitris N. "Operations Research for Industrial Management." New York, Reinold; London, Chapman and Hall, 1958. 303 pages. Diagrams. 70s.

"The purpose of this book is to present, explain and discuss some of the most recently developed analytic techniques in the area of managerial decision. Industrial and business concerns have to make two types of decision: (1) short-term day-to-day variety; (2) evaluation and selection of long-term courses of action. The greatest possibilities for operations research lie in the latter area." The emphasis in this book is on simulation studies. The book includes the application of operations research methods to financial allocation, transportation, inventory control and production set-ups.

Institution of Metallurgists, London. "The Structure of Metals: a Modern Conception." Lectures delivered at the Institution of Metallurgists Refresher Course, 1958. London, Iliffe and Sons for the Institution; New York, Interscience Publishers Inc., 1959. 118 pages. Plates, Diagrams. 25s.

This is the third volume of lectures delivered at Institution of Metallurgists Refresher Courses. The theme of the 1958 Course was a review of some modern theories of the structure of metals. In the first Paper Professor G. V. Raynor discusses the developments which have taken place during the last 30 years in the theory of the electron structure of metals. This is followed by a Paper by Doctor Catterall, who describes the experimental techniques developed to test the theory. Professor A. G. Quarrell discusses the dislocation theory of plastic deformation, and Doctor J. Nutting, shows that this theory has been justified by experiment, the techniques of which he describes.

American Society of Tool Engineers, Detroit, Michigan. "Collected Papers 1958." Technical Papers and Panel Conferences presented at the 26th semi-annual meeting. Detroit, the Society, 1958. 55 parts in binder, illustrated. Diagrams. £5.

The Papers are divided into the following sections: Product Engineering; Fabricating processes; Manufacturing planning and control; Tooling design; Metal working principles; Metal forming; Engineering materials; Quality control; Manufacturing management; General interest.

Benge, R. C. "Technical and Vocational Education in the United Kingdom: a Bibliographical Survey." Paris, UNESCO 1958. 51 pages. 5s. (Educational Studies and Documents, No. 27.)

An annotated bibliography.

Canada. National Research Council—Technical Information Service. "Time and Motion Study in the Construction Industry: a selected Annotated Bibliography." Ottawa, the Council, September, 1958. 8 pages Mimeo. (T.I.S. Report No. 27.)

Institution of Mechanical Engineers, London. "East Midlands Branch Spring Meeting." University of Nottingham, April, 1959. London, the Institution, 1959. Various paging. Illustrated. Diagrams. Mimeo.

Comprises a series of Papers on the challenge of foreign competition in the engineering industry, and future developments in engineering. The latter series includes Papers on the new metals, developments in machine tools and production methods, future trends of electronics in engineering, future developments in lubrication, future developments in corrosion prevention, and surface metrology.

Department of Scientific and Industrial Research. "Notes on D.S.I.R. Grants for Graduate Students and Research Workers." Revised 1959. London, the Department, 1959. 29 pages. 1s. 9d.

European Productivity Agency, Paris. "Technical Information and the Smaller Firm: Facts and Figures on Practices in European and American Industry." Paris, the Agency, 1958 (U.K. agent: H.M.S.O.) 69 pages. Tables. 4s. 6d. (E.P.A. Project No. 296/2.)

Describes the results of a survey of the methods used by small and medium-sized firms to obtain technical information. "The survey . . . was expected to show the kinds of problems which firms faced, their internal resources in terms of technical staff, research facilities and libraries, and where they might require supplementing, the external sources of information and new ideas which were being used, and the manner in which they were organised to profit from such factors. It was also hoped, too, that the inquiry would give some indication of the extent to which outside sources of new ideas could be developed and modified, the most appropriate levels for presenting these ideas, and the best channels to use if they were to reach different sized firms."

Gates, Philip. "Jigs, Tools and Fixtures: their Drawing and Design." 5th edition revised. London, Technical Press, 1959. 215 pages. Illustrated. Diagrams. 30s.

The author's aim has been to offer the machine shop apprentice and the junior in the drawing office, a general introduction to the main types of equipment used in connection with machine tools. This edition includes a new chapter on indexing mechanisms, a much extended chapter on press tools, and much additional information on special purpose equipment. Contents: Mechanical drawing—Sketching—First considerations in the design of jigs, tools and fixtures—Drill jigs—Milling fixtures—Chucks and turning equipment—Cutters—Screwing equipment—Gauges—Press tools—Cams for autos—Special equipment—Jig and tool office procedure—Jig bushes—Indexing devices—Magnetic and pneumatic gripping—Materials.

Hammond, Rolt. "Introduction to Dock and Harbour Engineering." London, Nelson, 1958. 160 pages. Illustrated. Diagrams. 25s.

"In this book the author has tried to review some of the complex problems which the engineer must solve if a port is to operate at maximum efficiency." Of particular interest to production engineers are the chapters on cargo handling, and on speeding turn-round. The author anticipates criticisms that the book is too elementary by saying that only if the basic principles of engineering are kept in mind can a modern port be made an international asset. Contents: The forces of the sea—Planning the harbour—Equipment for submarine work—Dredges and dredging—Ingenuity in dock and harbour construction—The harbour engineer in war—Oil handling in ports—Mechanical engineering in ports (deals chiefly with mechanical handling)—Transport facilities in and to ports.

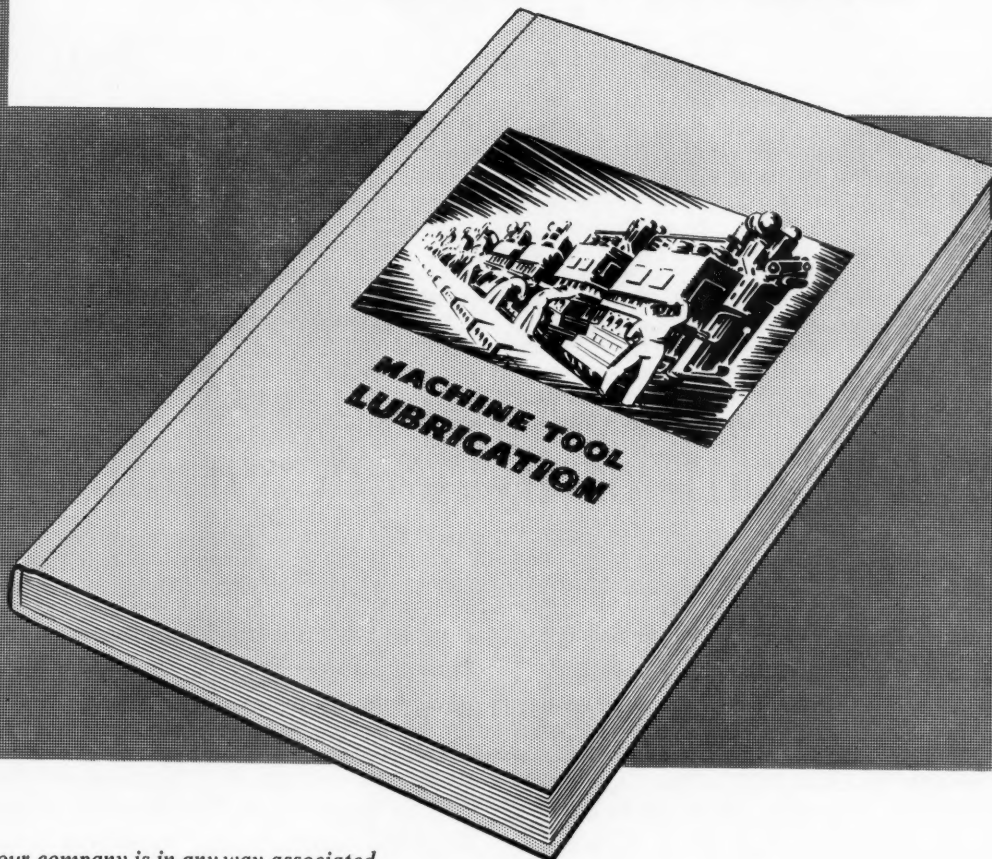
Jacobson, Howard Boons and Roucek, Joseph S. Editors. "Automation and Society." New York, Philosophical Library, 1959. \$10.00.

Thirty-two studies by different authors of the economic, social and other consequences of "automation" to society in general, to specific industries and classes of worker, and to the individual person.

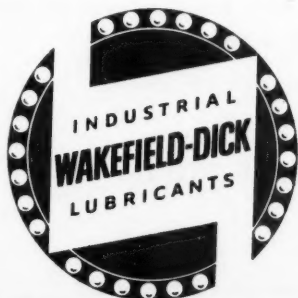
Lot, Fernand. "Radioisotopes in the Service of Man." Paris, UNESCO, 1959. 82 pages. Illustrated. Diagrams. 5s.

A popular account of the applications of radioisotopes.

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JE




There's talk of Sykes down under

Some time ago a Commonwealth visitor to Britain heard about Sykes' reputation for solving problems of gear production. This man's business was agricultural equipment, and he believed there was a good market in his country for a power 'take-off' unit, which could operate equipment such as milking and ditching machines, water pumps, power clippers, etc. But although he could visualize the mechanics of his invention he was uncertain about some of the technical details of the gearing involved.

He found this was the kind of problem Sykes take easily in their stride. Years of work at their main business of supplying first-class generating machines and equipment—hobbers, shavers, shapers, and

cutters—has given them an unequalled store of expert knowledge and experience in this field. And through their Technical Sales Advisory Service this accumulated knowledge is available to everyone who comes to Sykes for service.

Thus this important Commonwealth visitor soon found the technical advice he had been looking for. Now, on the other side of the world, he has a factory producing power 'take-off' units—an enterprise which might never have been realized had he not initially come to Sykes for technical advice. Sykes had not only designed the gears, but had also advised on the most efficient and economical production methods and schedules.


Talk to SYKES about gear production

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Midlands	...	A. C. Turner	South Eastern	...	J. Aikman
North Midlands	...	J. Cox	Southern	...	W. F. Reid
Northern	...	A. Smith	South Western	...	A. Eustace
North Western	...	J. P. Speakman	Wales	...	R. E. Haynes

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Melbourne (Victoria, Australia)	A. G. Jones, 13 Laburnum Street, Middle Brighton, Victoria, Australia.
Melbourne Graduate (Victoria Australia) ...	E. K. Stephenson, 5 Olinda Street, Glen Waverley, Melbourne, Victoria, Australia.
Sydney (New South Wales)	K. G. Slorach, 98 Church Street, Castle Hill, New South Wales, Australia.

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Calcutta ...	P. J. O'Leary, c/o Guest, Keen, Williams Ltd., 41 Chowringhee Road, Calcutta, India.

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South Africa ...	A. Aitken, 209-211 Pharmacy House, 80 Jorissen Street, Johannesburg, P.O. Box 10837, South Africa.
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Doncaster ...	G. R. Wimpenny, 16 Tickhill Square, Denaby Main, Doncaster.
Dundee ...	A. J. Fraser, 51 Fintry Drive, Dundee.
Edinburgh ...	D. A. Bowman, The Scottish Council (Dev. and Ind.), 1 Castle Street, Edinburgh.
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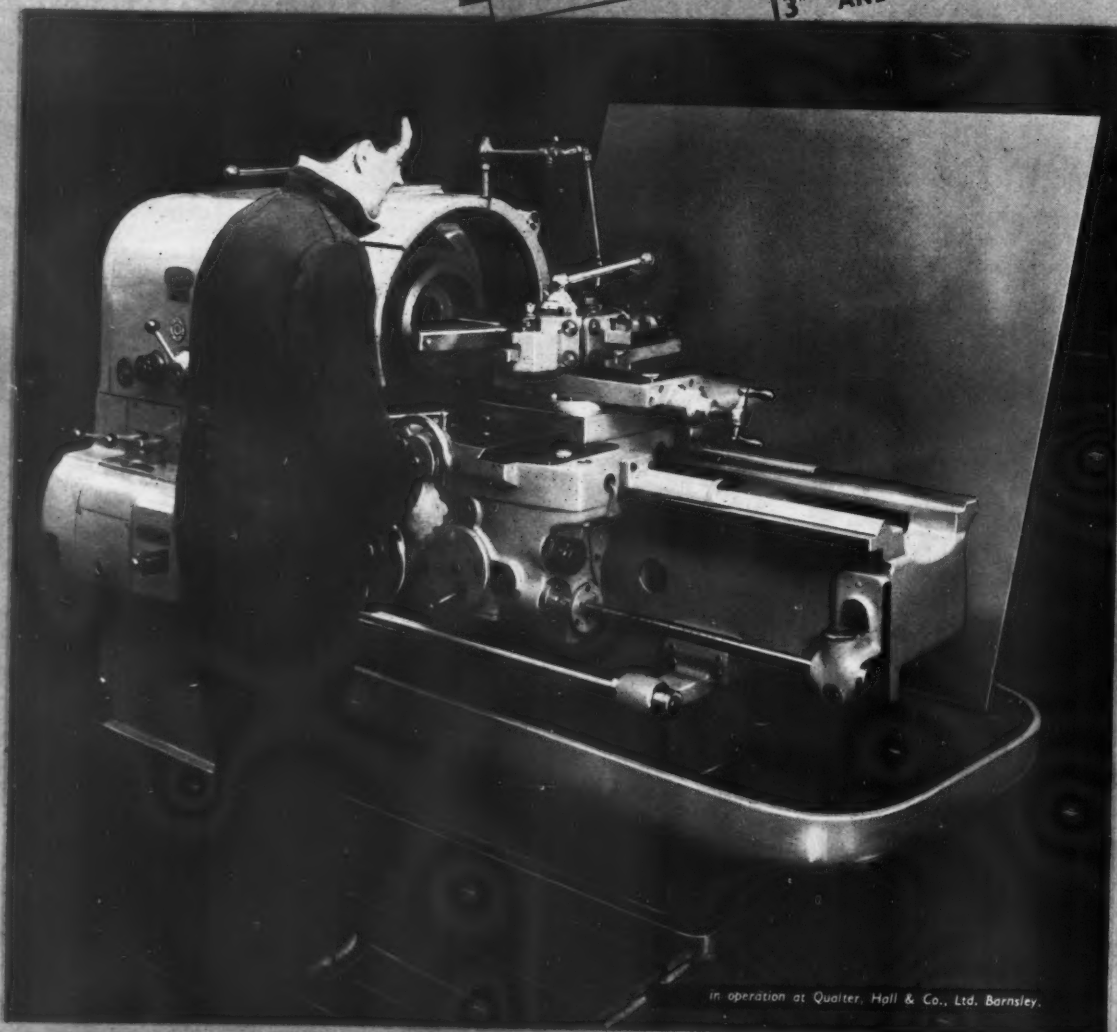
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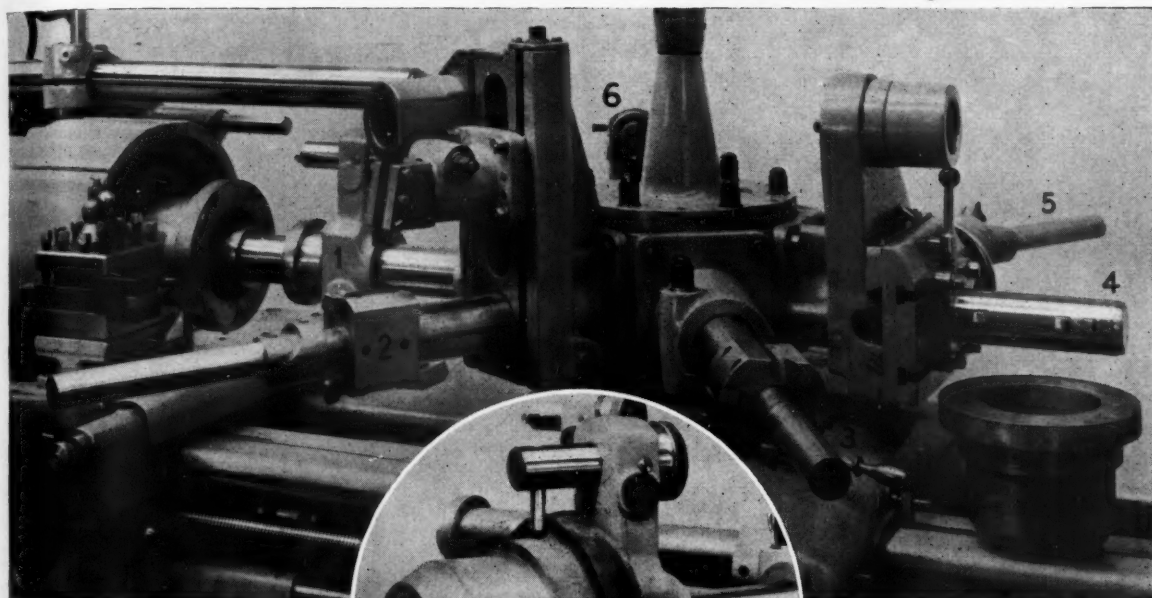
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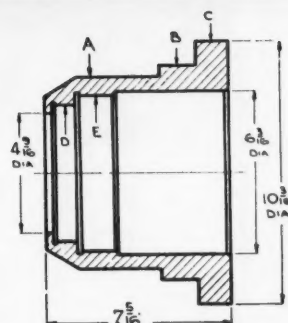


PULLEY SLEEVE

Ward

No. 8 TURRET LATHE

FITTED WITH 15in TUDOR 3-JAW CHUCK



Tungsten Carbide Cutting Tools

CAST IRON CASTING

Floor-to-Floor Time:
13 mins. each.

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per Inch
	Hex. Turret	Cross-slide			
1. Chuck on A (using Loading Attachment) -	1	—	—	—	—
Rough Face and Rough Turn C (1st cut)	—	Front 1	85	235	48
2. Rough Bore $6\frac{3}{16}$ and $4\frac{9}{16}$ and Rough Turn C -	2	—	85	230	70
3. Rough Bore D and E -	3	—	85	133	70
Rough Turn B and Face Back of Flange	—	Front 2	85	225	70
4. Undercut and Chamfer Bores (Recessing Toolholder) -	4	—	85	133	Hand
Microbore D, E and $6\frac{3}{16}$ dias. -	5	—	175	285	98
5. Finish Turn C -	—	Front 3	175	465	70
Finish Double Face Flange -	—	Front 4	175	465	70
6. Remove Part from Chuck (using Unloading Attachment) -	6	—	—	—	—

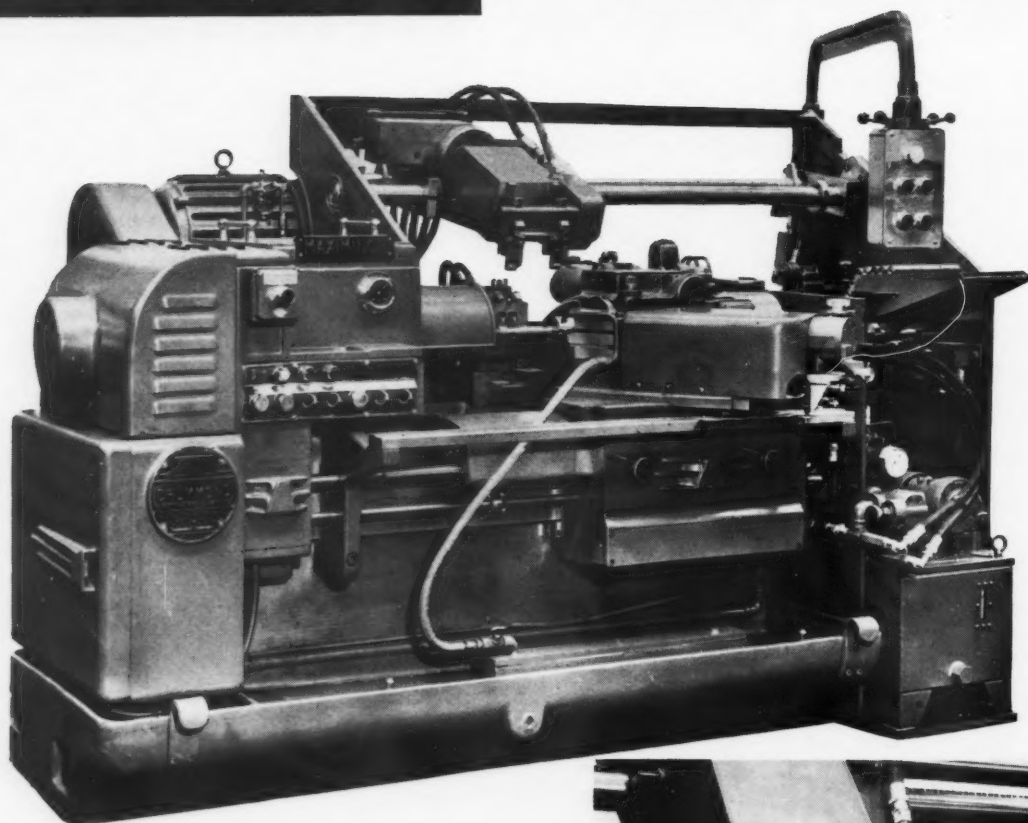
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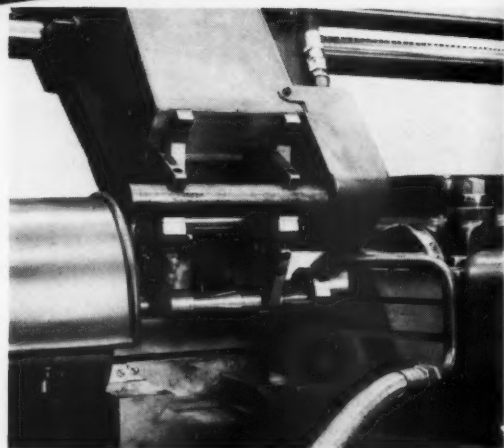
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THE IDEAL AUTOMATIC PRODUCTION LATHE



with combined Multi - Tool and Copy Turning Features

This MAXIMINOR with both Multi-Tool and Copy Turning Features enables the advantages of these two techniques to be applied to production in one Automatic Cycle of operation. Automatic Handling Equipment can also be fitted. The close-up view shows the copy turning slide in the right foreground, the multi-tool slide at the rear, and a blank workpiece about to be inserted between centres in place of the machined component.



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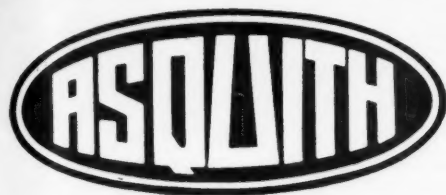
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IN - LINE TRANSFER MACHINE FOR *Austin* CYLINDER BLOCKS

This Asquith 14-station in-line transfer machine provides, among other operations, for semi-finish and finish boring crankshaft and camshaft bores; boring and facing a recess for the oil pump; milling thrust bearing faces on the central crankshaft bearing and reaming the crankshaft and camshaft bores. A split liner bush is also pressed in and fine bored in position.

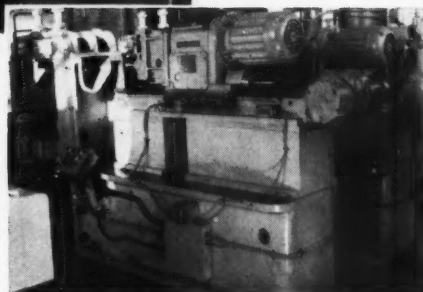
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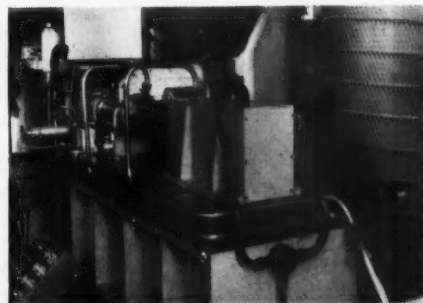
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Two 3 h.p. Asquith Unit Heads which finish ream the crankshaft and camshaft bores.



Hydraulically operated pressing station for inserting liner bushes.

*drilling history



<i>Material</i>	<i>Hardened armour-plate, considered too hard for drilling, cast to include holes.</i>
<i>Problem</i>	<i>To drill 1" holes in this armour-plate.</i>
<i>Solution</i>	<i>R.T.D. Compound applied to drill and plate-face. Eight 1" holes were drilled before the tool needed regrinding.</i>

Armour-plate is not usually encountered in toolroom or machine-shop; but the tough new alloy steels and nickels are becoming almost daily problems.

ROCOL R.T.D. COMPOUND is a specially designed lubricant for conditions in which the tool sustains extreme pressures, and frictional heat, galling,

scuffing, wear and seizure are experienced.

R.T.D. COMPOUND resists the extreme pressures of the most severe machining processes and produces smooth cutting with minimum wear.

ROCOL R.T.D. COMPOUND shortens job-time — and lengthens tool-life!

* From the Rocol R.T.D. book of industrial case-histories.

WRITE TO ROCOL ABOUT LUBRICATION

R.T.D.

COMPOUND

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More advantages

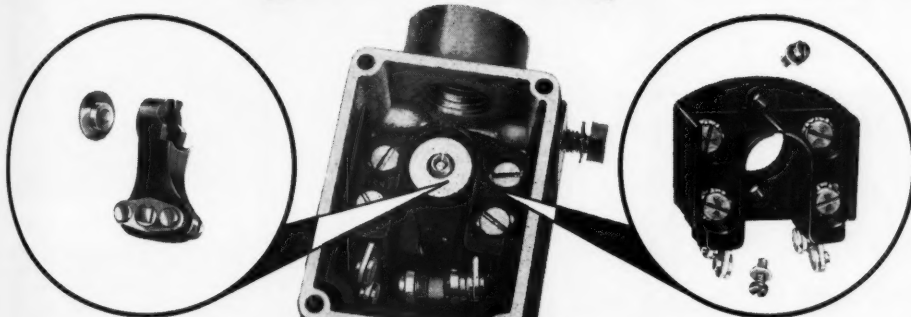


in Mark II

SNAP-LOCK

A TYPE APPLICABLE TO EVERY INDUSTRY
heavy duty limit switches

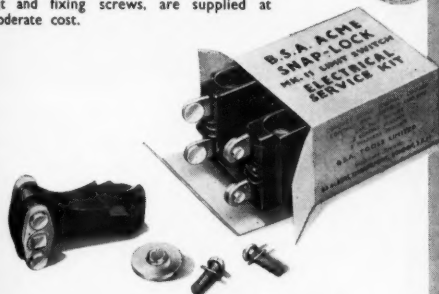
**WATER
OIL
AND
DUSTPROOF
OR
FLAMEPROOF
VERSIONS**



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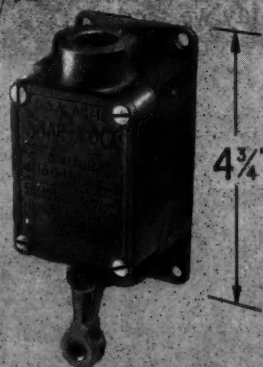
**TWO ONLY
REPLACEABLE UNITS IN
THE ELECTRICAL SIDE**

There are only two assemblies in the electrical side of B.S.A. ACME SNAP-LOCK Mk. II limit switches: a moulded one-piece contact block and the contact arm. Interchangeable on all models they are designed for easy replacement. Service kits comprising these items, complete with holding nut and fixing screws, are supplied at moderate cost.



B.S.A. Acme Snap-Lock heavy duty limit switches have an established reputation for reliability under the most arduous conditions. Recently introduced Mark II versions retain proved features of their forerunners but incorporate refinements in design and manufacture principally to simplify servicing, provide complete interchangeability of assemblies, increase electrical resistance to earth and ensure lasting efficient sealing. Please ask for the Mark II catalogue.

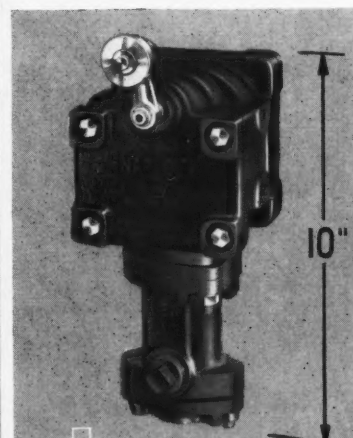
**STANDARD
NEUTRAL POSITION
OR
CENTRE CONNECTION**



STANDARD

WATER, OIL & DUST PROOF

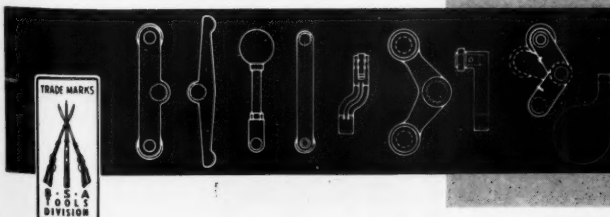
Single pole, double break, double throw, operates with either circuit normally open with other closed, or maintaining in either position, or available with central (neutral) position and/or centre connection. Heavy aluminium die-cast case. Water, oil and dust proof. Conduit 1 in. B.S. or No. 3 Admiralty Pattern Cable gland entry. Two-screw side mounting or backplate mounting in two styles, or Tandem style (back to back mounting). Operating lever position adjustable in 7.5 deg. increments through 82.5 deg. either way from normal.



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Buxton certificates No. 3574 (Group I) No. 3575 (Groups II and III gases). Mechanite iron castings. Self-wiping solid silver contacts, interchangeable plugs and sockets. Internal mechanism removable as a unit for servicing. Single SWA cable entry (standard); double entry if required. Operating lever position adjustable in 7.5 deg. increments through 360 degs. Single pole, double break, having one normally closed and one normally open circuit. Available with central (Neutral) position and/or centre connection.



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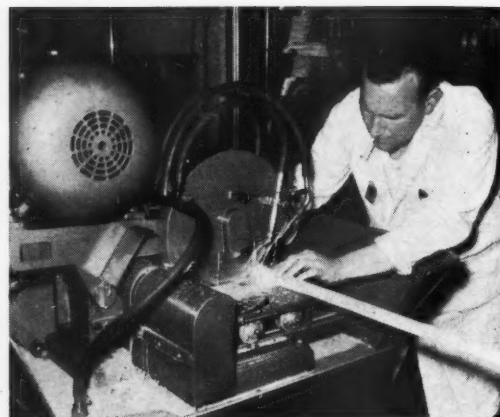
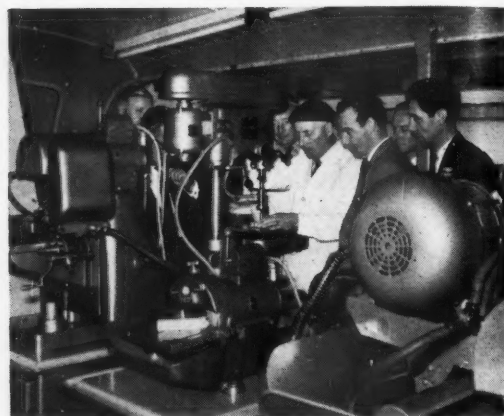
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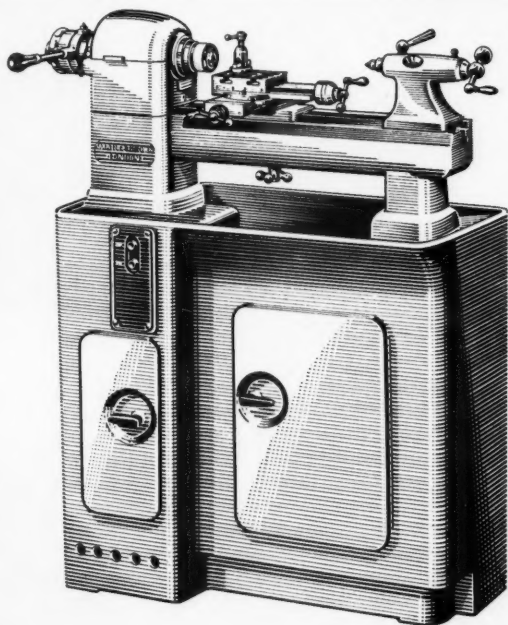
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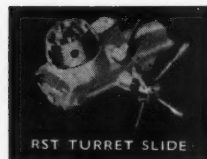
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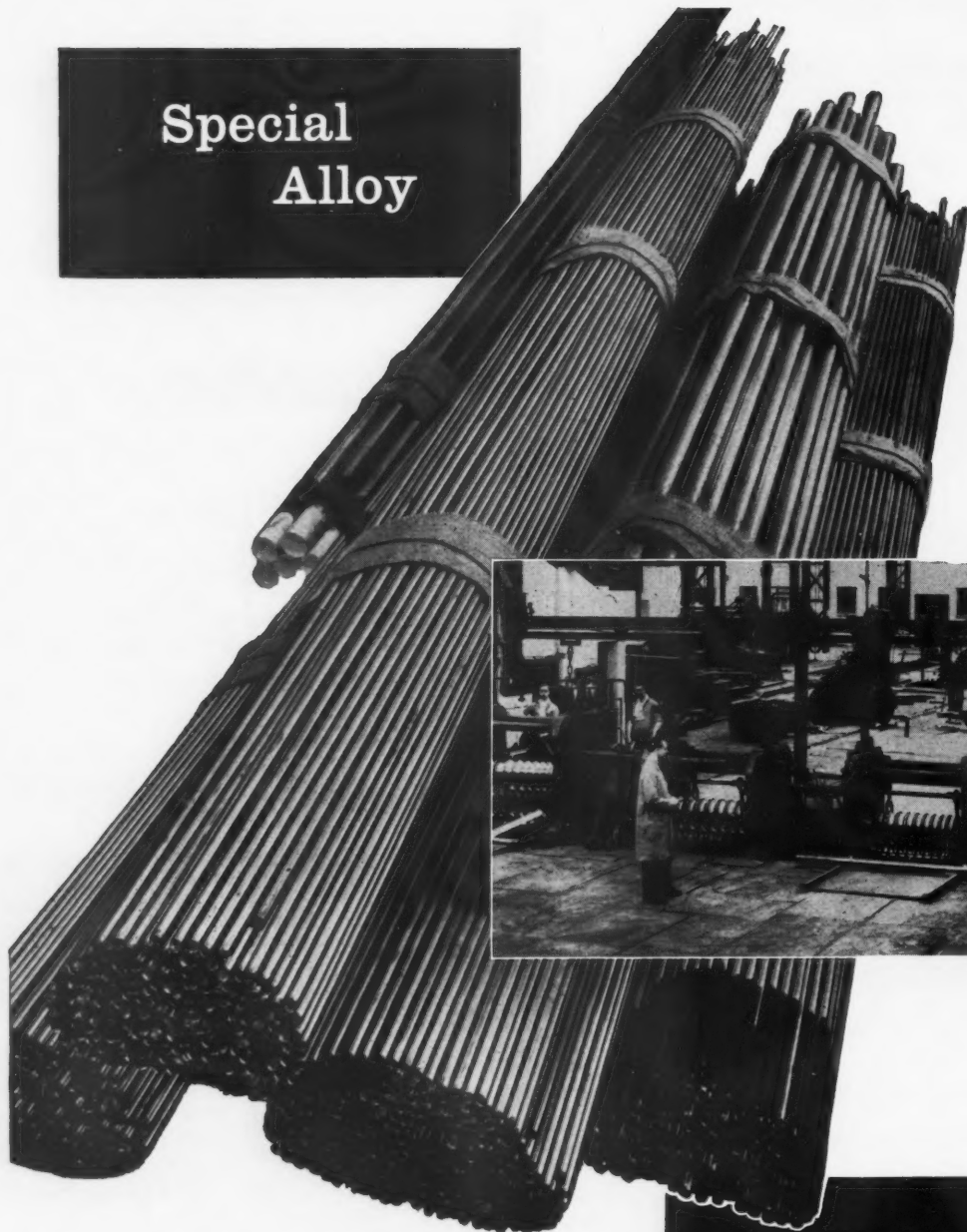
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The problem of fine boring close centre holes in this Rover gearbox is ingeniously overcome by use of the PRECIMAX three position hydraulically operated cross slide. The necessary transverse movements are preselected and linked with the longitudinal feed motions in a fully automatic cycle.

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2 h.p. motor, 8 speeds, 30-437 r.p.m.
Also alternatives:
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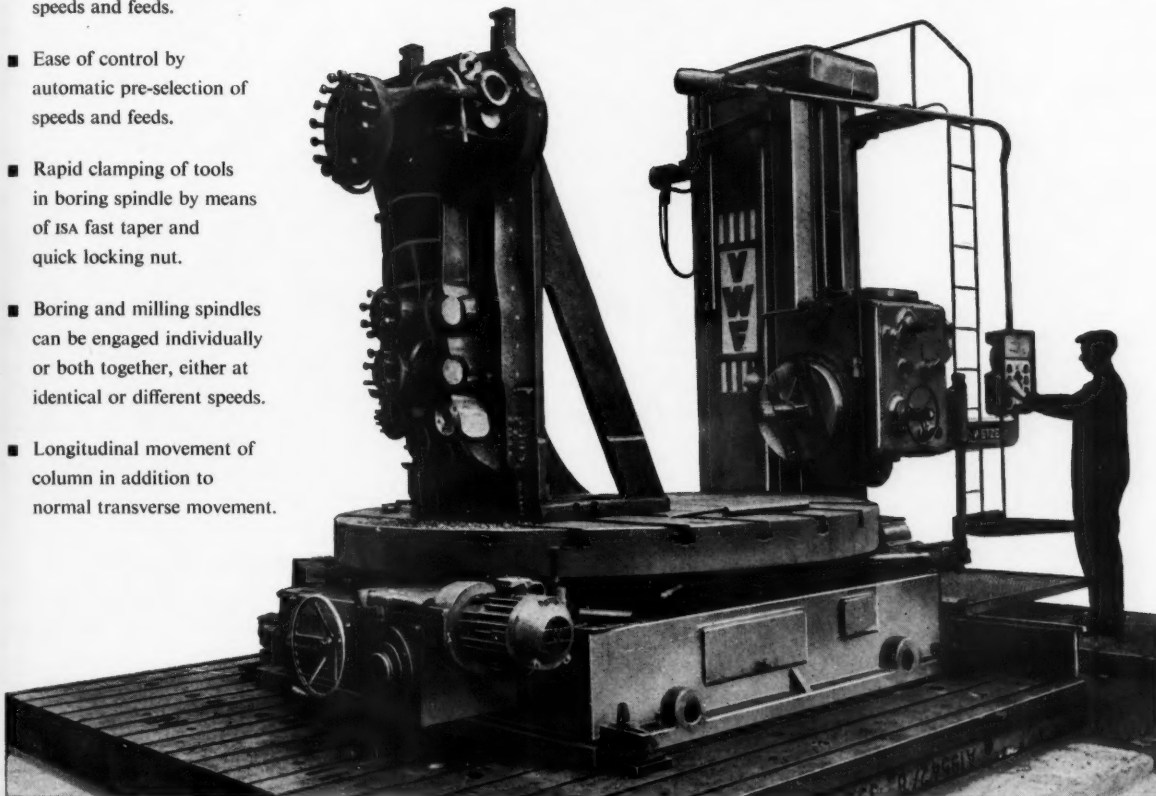
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BRIGHOUSE YORKS**

PHONE :— BRIGHOUSE 627 (3 LINES)

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VWF PLAUERT-WETZEL Horizontal Boring and Milling Machines

- Wide range of spindle speeds and feeds.
- Ease of control by automatic pre-selection of speeds and feeds.
- Rapid clamping of tools in boring spindle by means of ISA fast taper and quick locking nut.
- Boring and milling spindles can be engaged individually or both together, either at identical or different speeds.
- Longitudinal movement of column in addition to normal transverse movement.



Brief description MODEL BFKn (Floor plate type)

	100/180	125/200	180/280
Boring Spindle diameter	3.9"	4.9"	7.1"
Milling Spindle diameter	7.1"	7.9"	11.0"
Distance Floor Plate to spindle centre	41"/96"	45"/116"	43.3"/157.5"
Transverse column travel	108"	138"	167"
Longitudinal column travel	15.8"	19.7"	24.8"
Depth bored in one pass/second pass	35"/14"	44"/18"	49"/25"
Maximum boring diameter	35"	44"	55.1"
Maximum milling cutter diameter	20"	25"	31.5"
Maximum facing diameter	44"	51"	59"
Number of spindle speeds	23	33	24
Range of boring spindle speeds	9-1400	5.6-1000	4-800 r.p.m.
Range of milling spindle speeds	9-315	5.6-280	4-125 r.p.m.
Number of fine feeds	36	36	*
Range, per rev. of boring spindle	.0008"-47"	.0008"-47"	*
Number of coarse feeds	18	18	*
Range in inches/min.	1.02"-49"	1.02"-49"	*
Main motor capacity	20 H.P.	27 H.P.	55 H.P.
Weight without steady, and floor plate	16 TONS	25 TONS	51 TONS

★ Infinitely variable. Fuller details on request.

The photograph above is reproduced by courtesy of Messrs. C. A. Parsons & Co. Ltd., and shows the BFKn 125 installed in their Heavy Machine Shop.

The following machines are also available:—Table-Type Horizontal Boring Model BFh, Planing Machines, High Speed Dieing Presses and Pressure Die Casting Machines.

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Type 5D Ungeared Rigid Press.

The Butterley range of sheet metal machinery includes geared and ungeared power presses, guillotine shears, press brakes and general machinery for the hot and cold working of metals. All castings are made by the "Meehanite" process in our own well-equipped foundries. The Butterley foundries are available for the production of high-grade "Meehanite" castings to customers' requirements.

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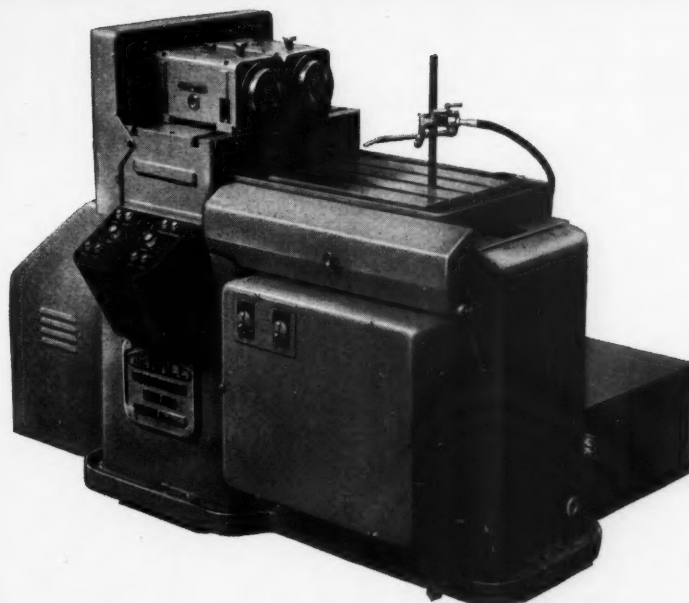
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Table surface	15 $\frac{3}{4}$ " x 22 $\frac{3}{4}$ "
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130°C

New triple life



Refer for Shell Alvania

For years now Shell Alvania greases have been a byword for stability in roller bearings. What is the secret? Lithium 12 hydroxy stearate, one of Shell's prized patents.

But stability is not enough. As new industrial techniques have been developed and new machines evolved, new problems have emerged with them and old problems have been intensified. Shell research teams at Thornton have made it their business to find the answers.

First problem was the *length of life of the grease charge* at the higher running temperatures of some modern machines. Could this life be lengthened? Shell scientists, through new Shell Alvania, have given an emphatic answer – at 130°C., the danger mark where most greases fail quickly through dynamic oxidation, Shell Alvania will live three times as long.

The second associated problem was the oxidation promoted by yellow metal cages. Could this

be reduced? The answer, in Shell Alvania, is the virtual suppression of the effects of yellow metal.

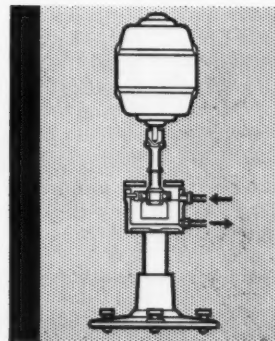
Problem three was corrosion caused by moisture. Could this be prevented? The answer was given in the Thornton Wet Bearing Rig Test*, where new Shell Alvania won an anti-corrosion rating of 10 out of 10.

New Shell Alvania greases were put on the market in March, 1957, and already, as proof of their success, tens of thousands of new electric motors leave British makers' works each week with Shell Alvania greases in their bearings.

What is the moral of the Shell Alvania Story? That Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right grease for the job. If you and your organisation have any major lubrication problems, it will pay you to get in touch with your local distributor of Shell Industrial Lubricants.

The Research Story

* In the Thornton Wet Bearing Rig Test, water was fed through a 20 mm. bore bearing with a special demountable plastic cage (to simplify inspection) charged with the grease under examination to a weighed quantity rotating at 3,000 r.p.m. The rate of supply of water was one gallon per minute, the water running to waste. After 5 hours' operation the bearing was removed and stored horizontally half immersed in water for three days. Anti-corrosion merit ratings were given at the end of the test. High-quality greases without special protectives showed an average rating of 3 out of 10, while new Shell Alvania rated 10 out of 10.



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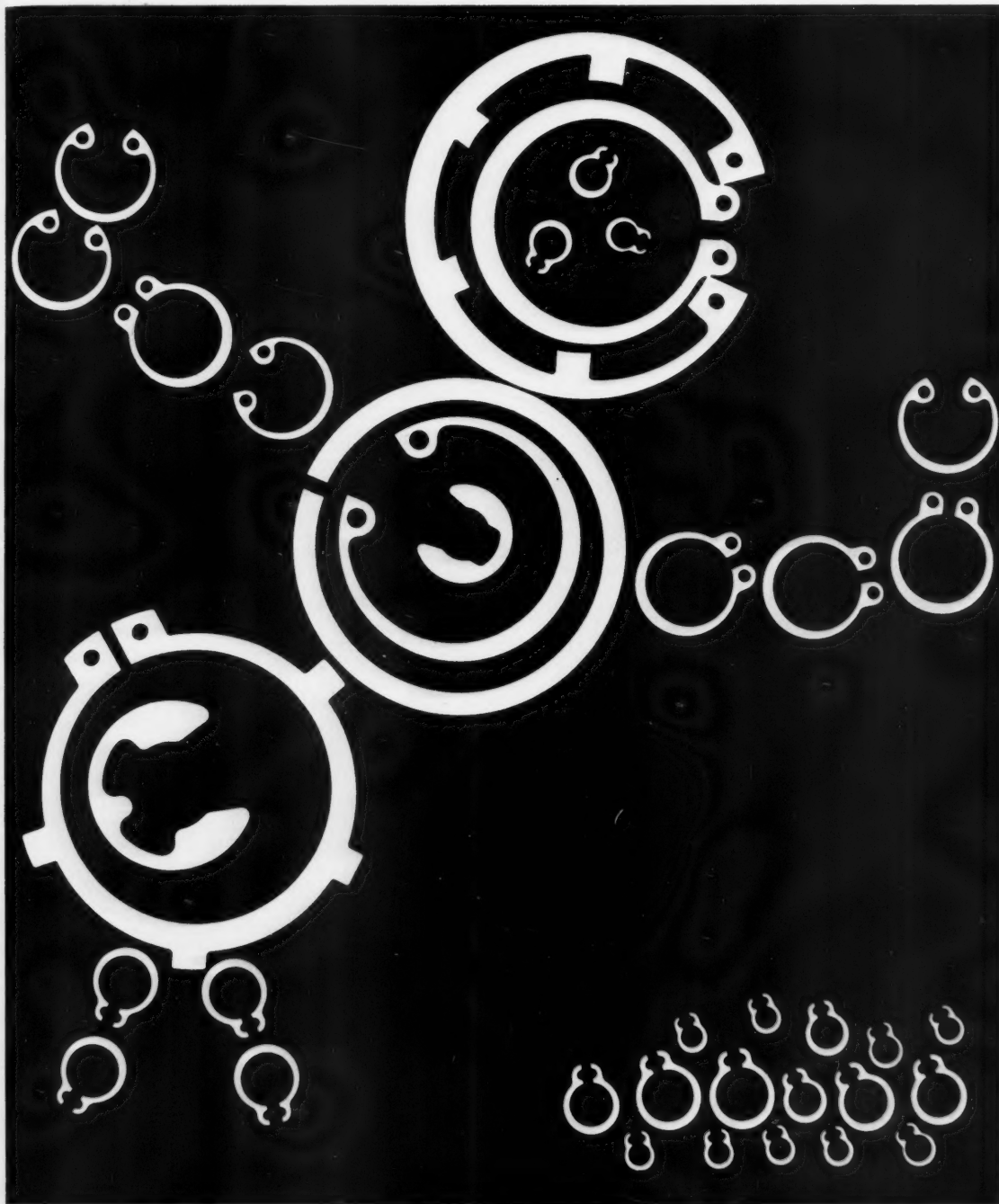
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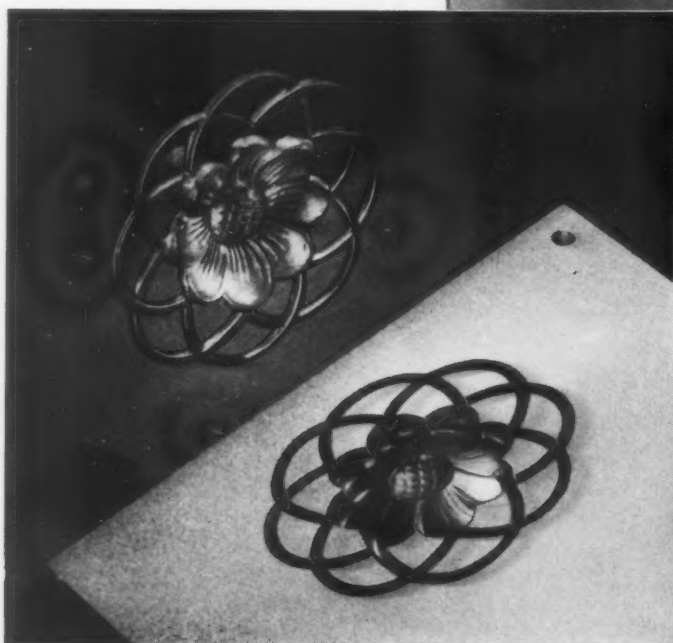
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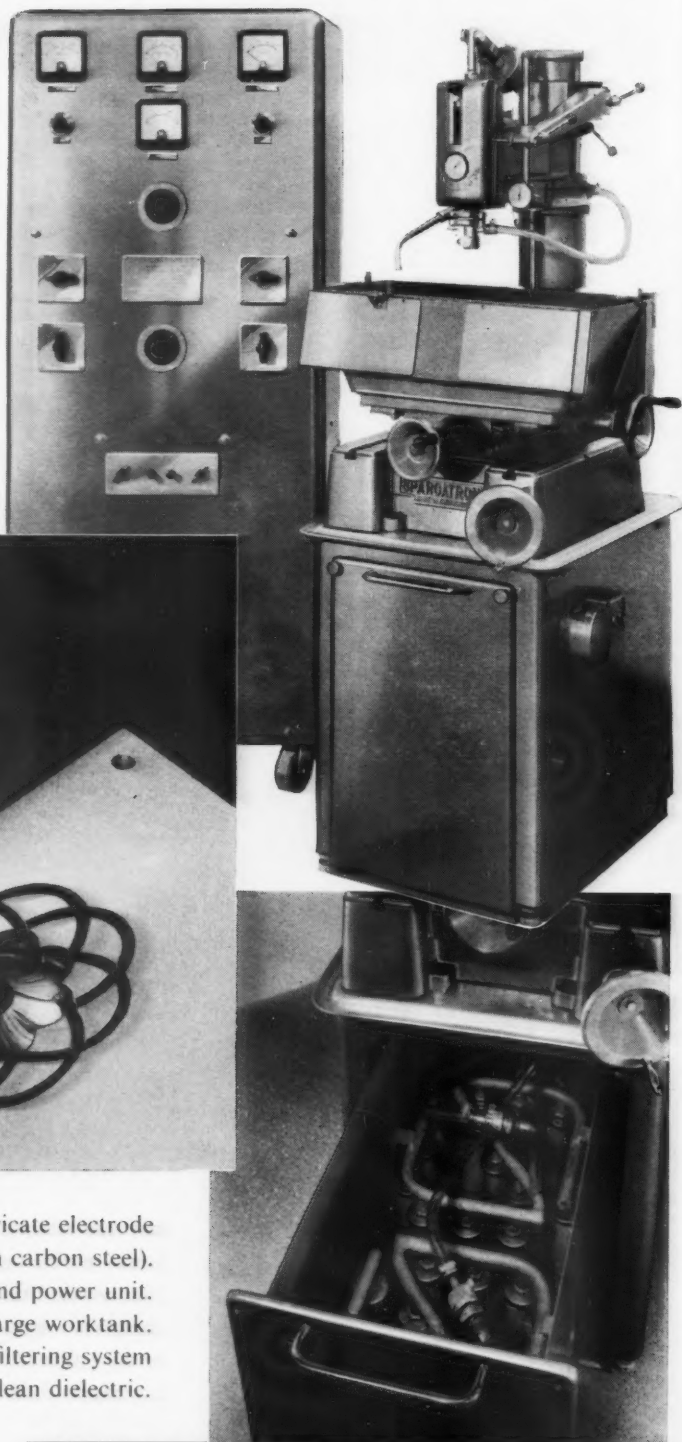
SPARK MACHINED from the SOLID



(Above) An intricate electrode (Mazak) and finished workpiece (high carbon steel).

(Top Right) the machine and power unit. Note the extra-large worktank.

(Right) new filtering system to ensure clean dielectric.



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This is only one of the countless applications for the Dawson metal cleaning and de-greasing machines which are widely used in every grade of engineering from electric shaver components to heavy diesel cylinder blocks.

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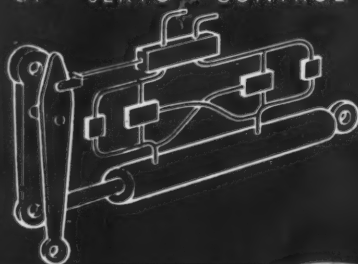
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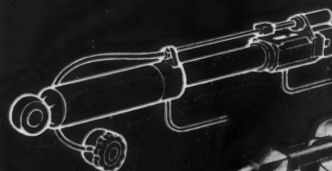
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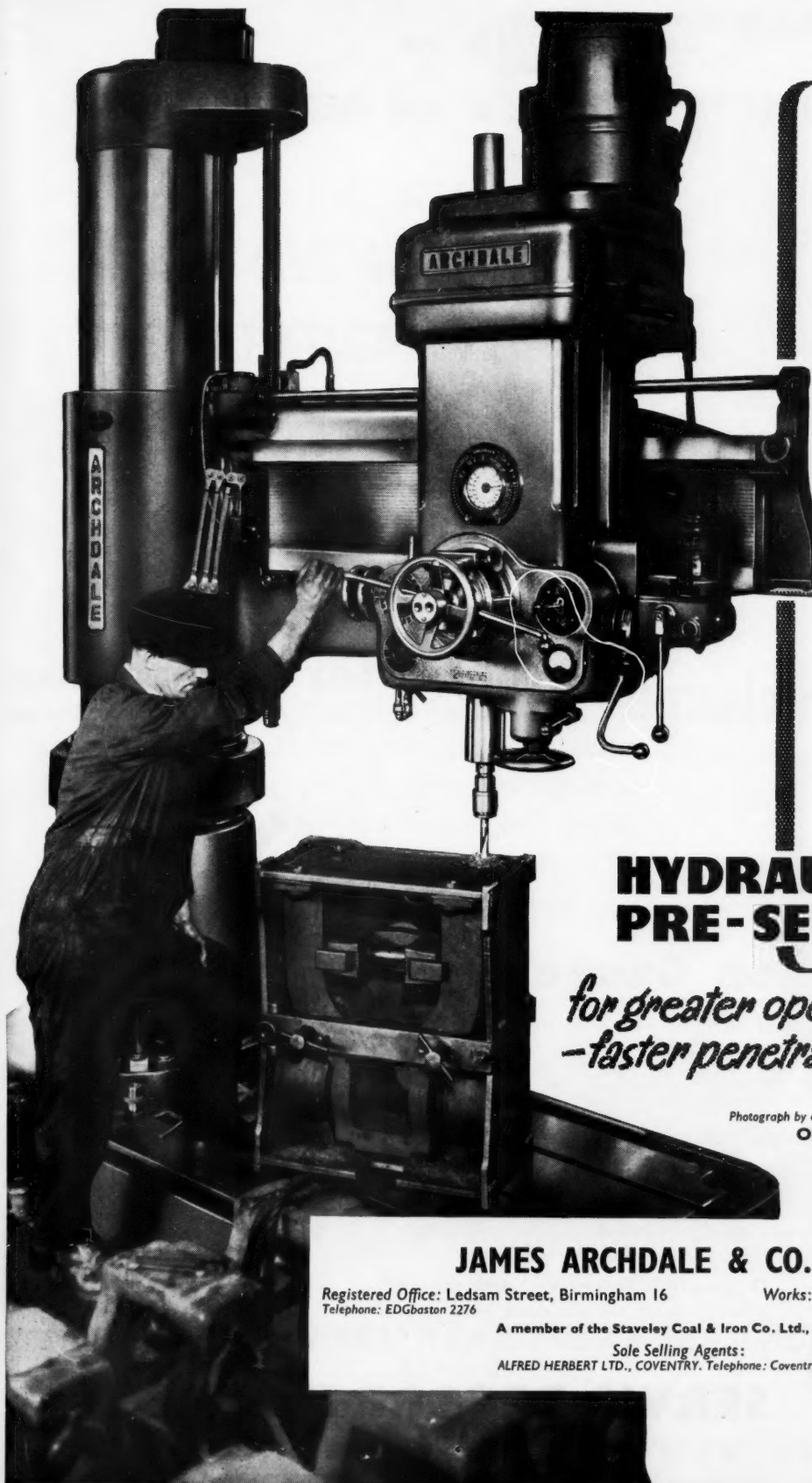
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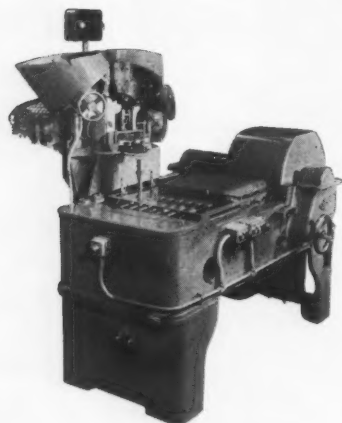
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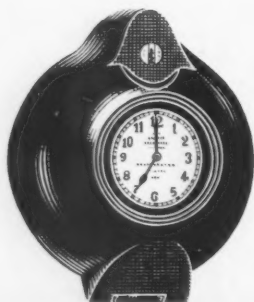
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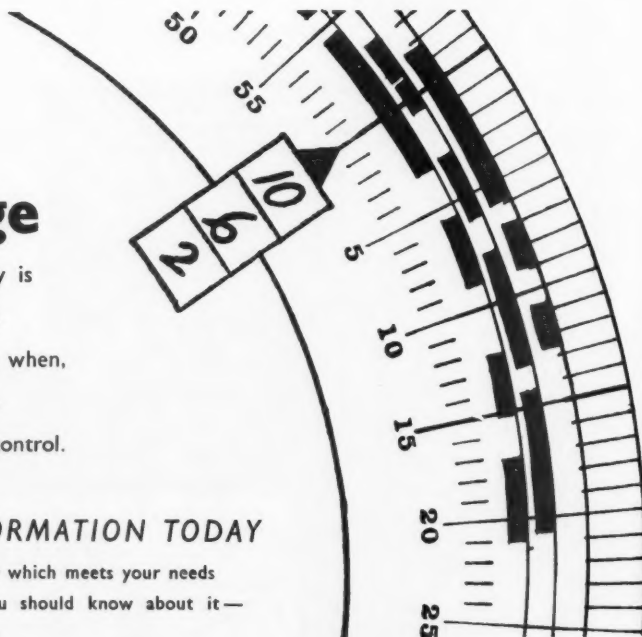
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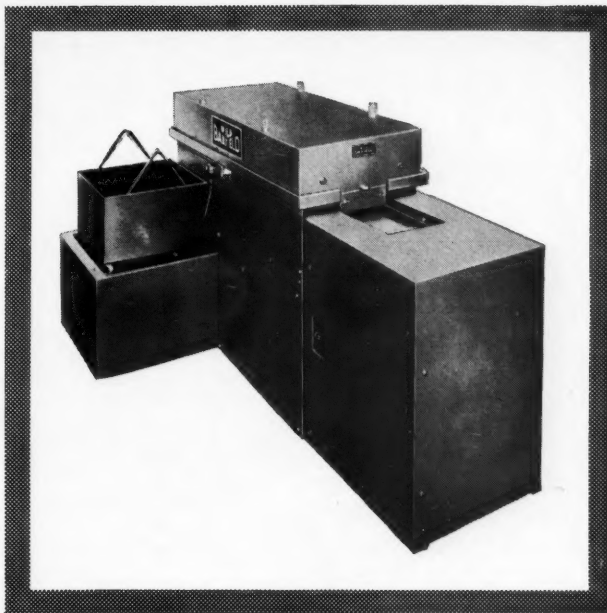
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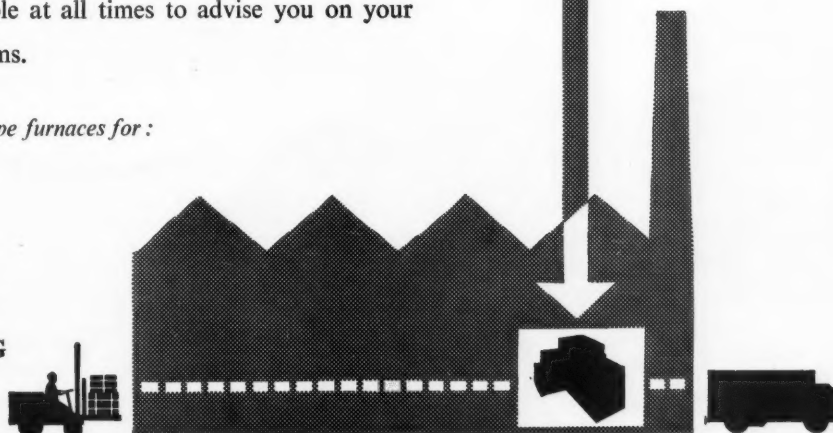
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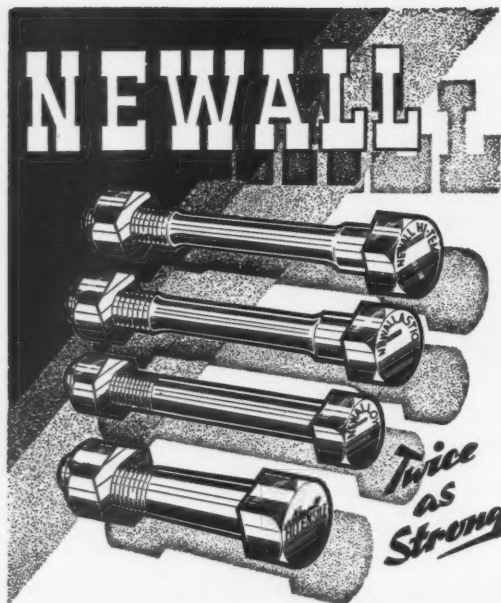


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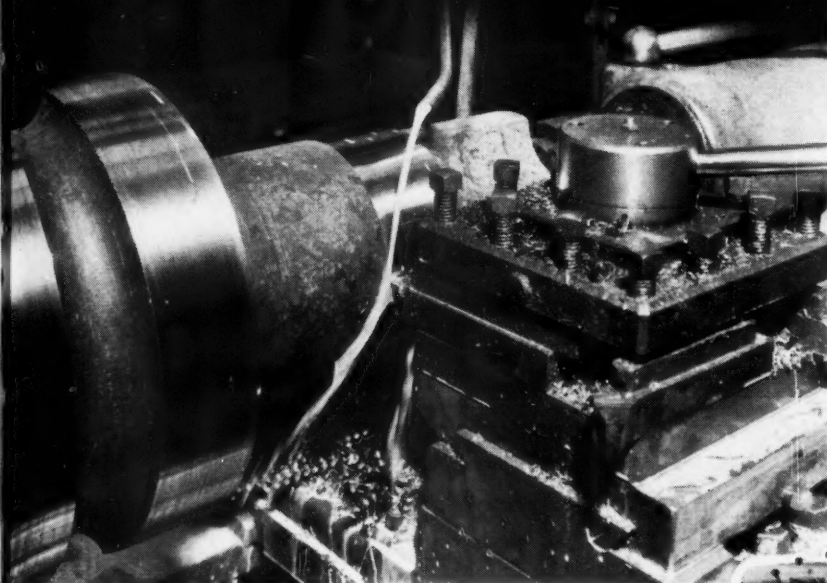
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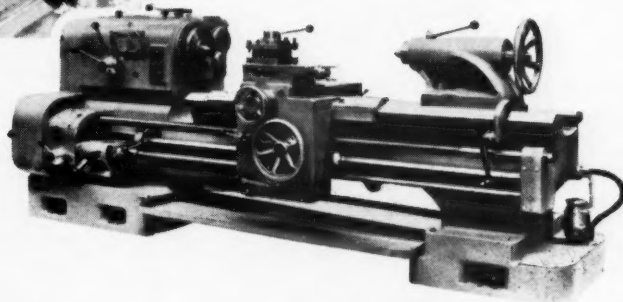


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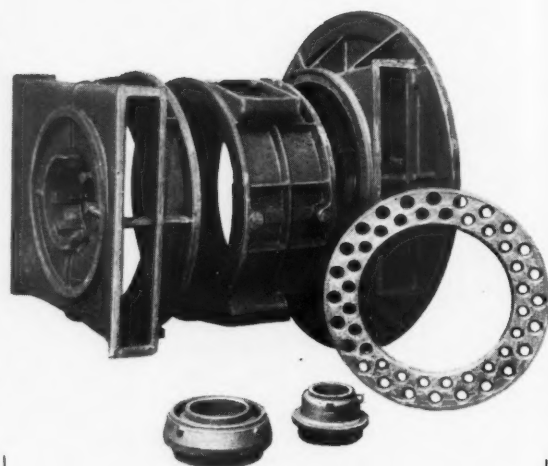
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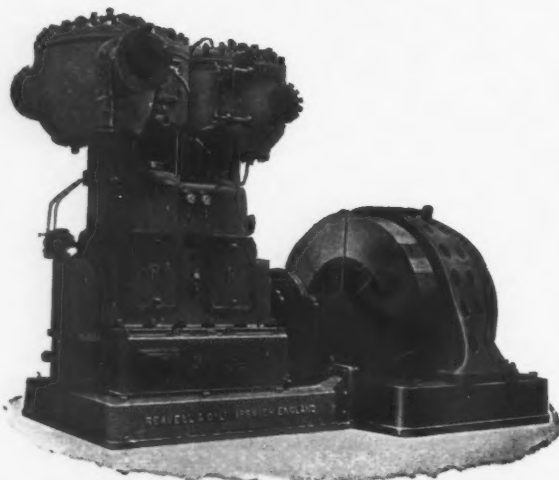
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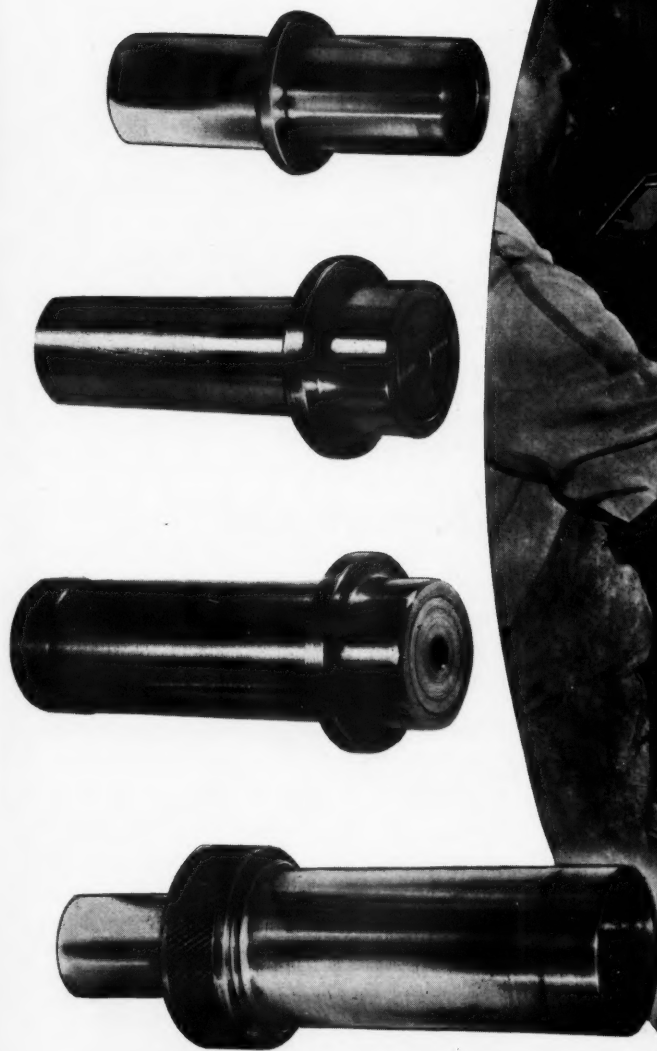
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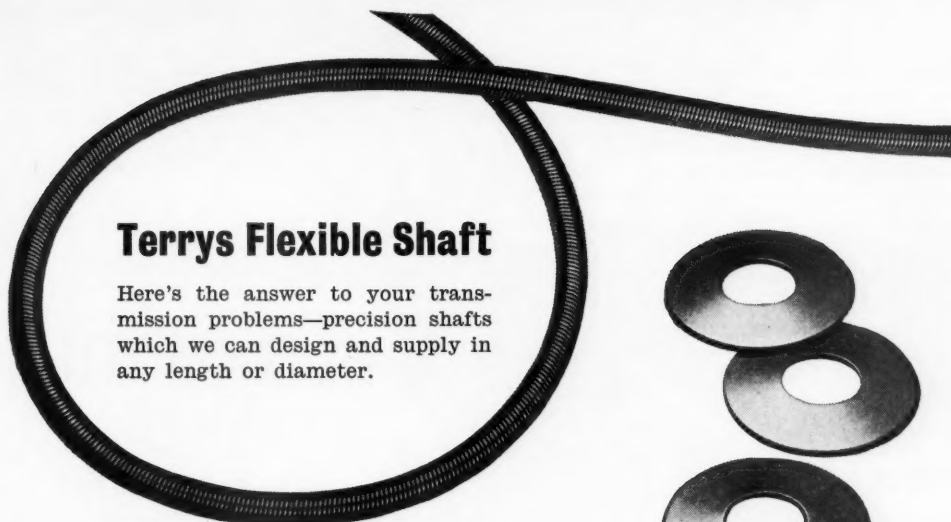
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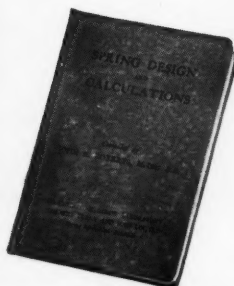
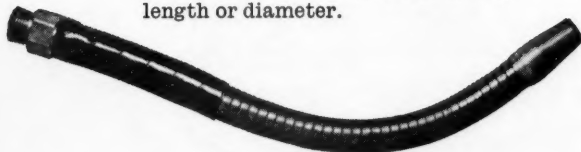


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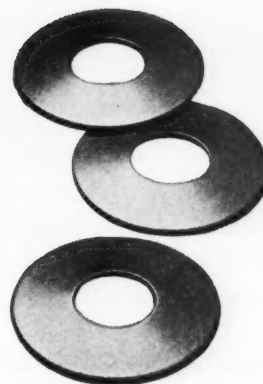
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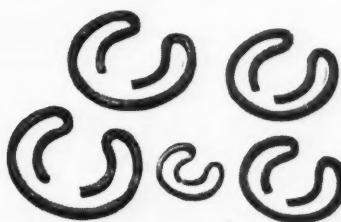
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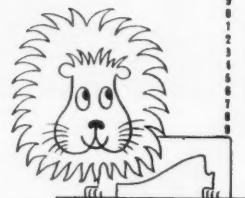
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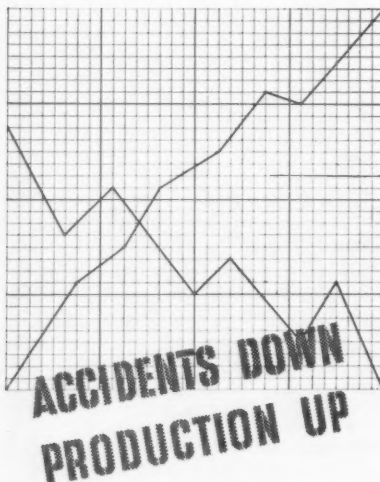


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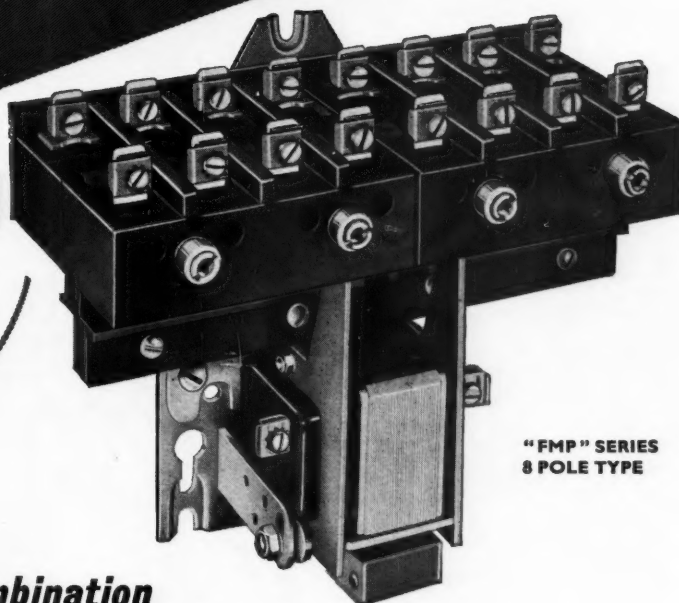
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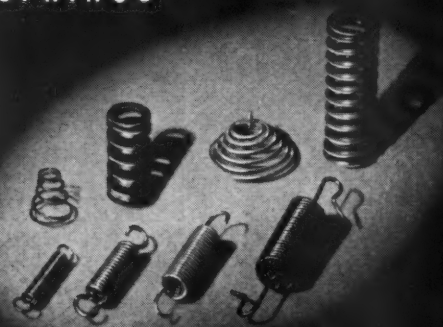
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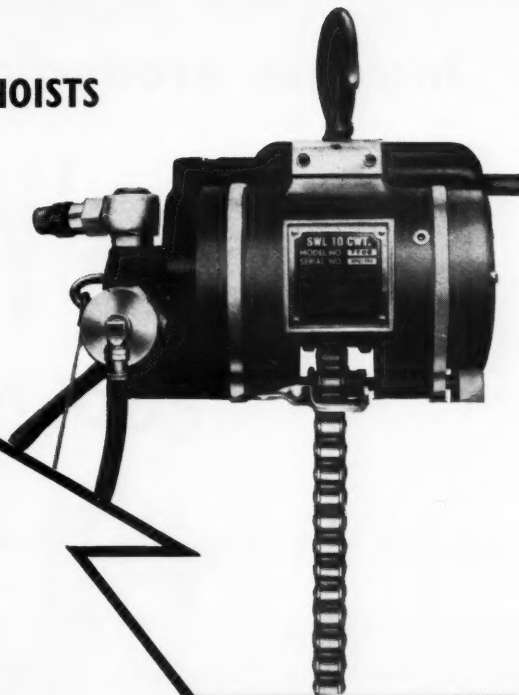
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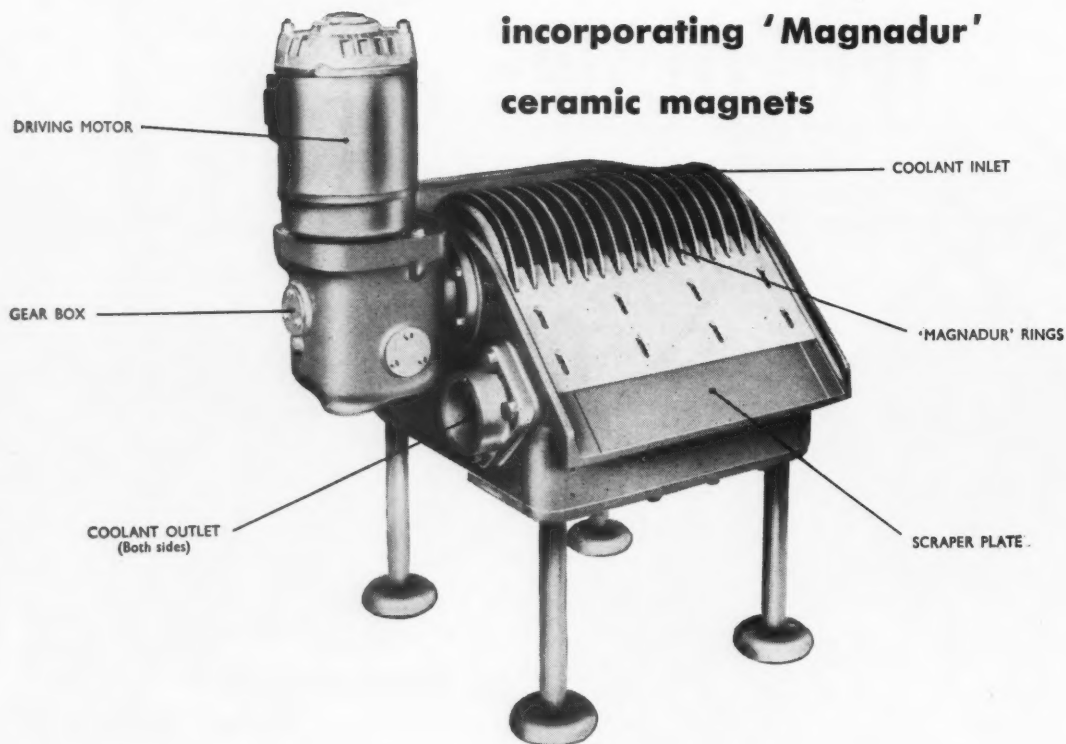
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658 SAS

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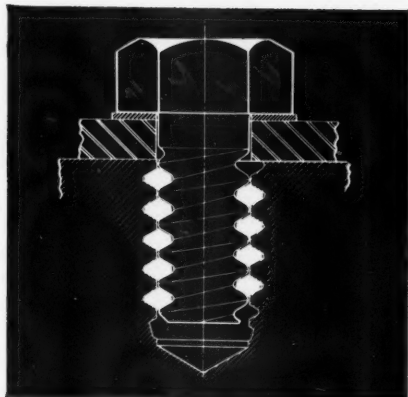
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* Heli-Coil is a registered trade mark

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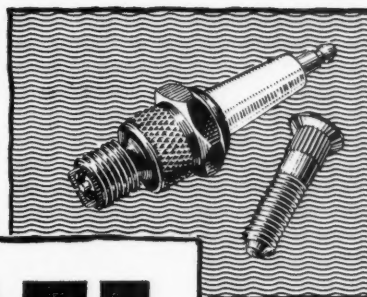
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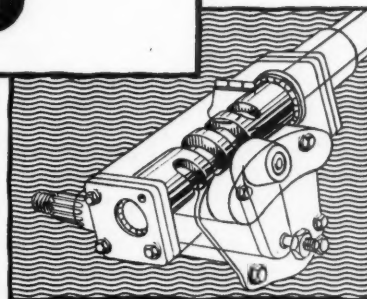
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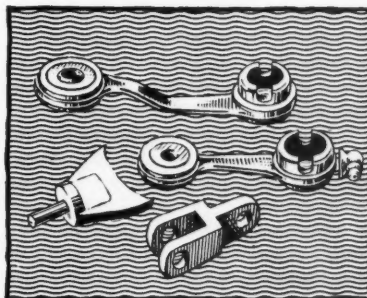
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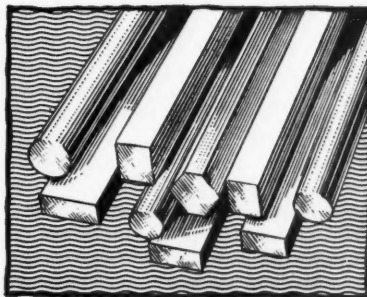
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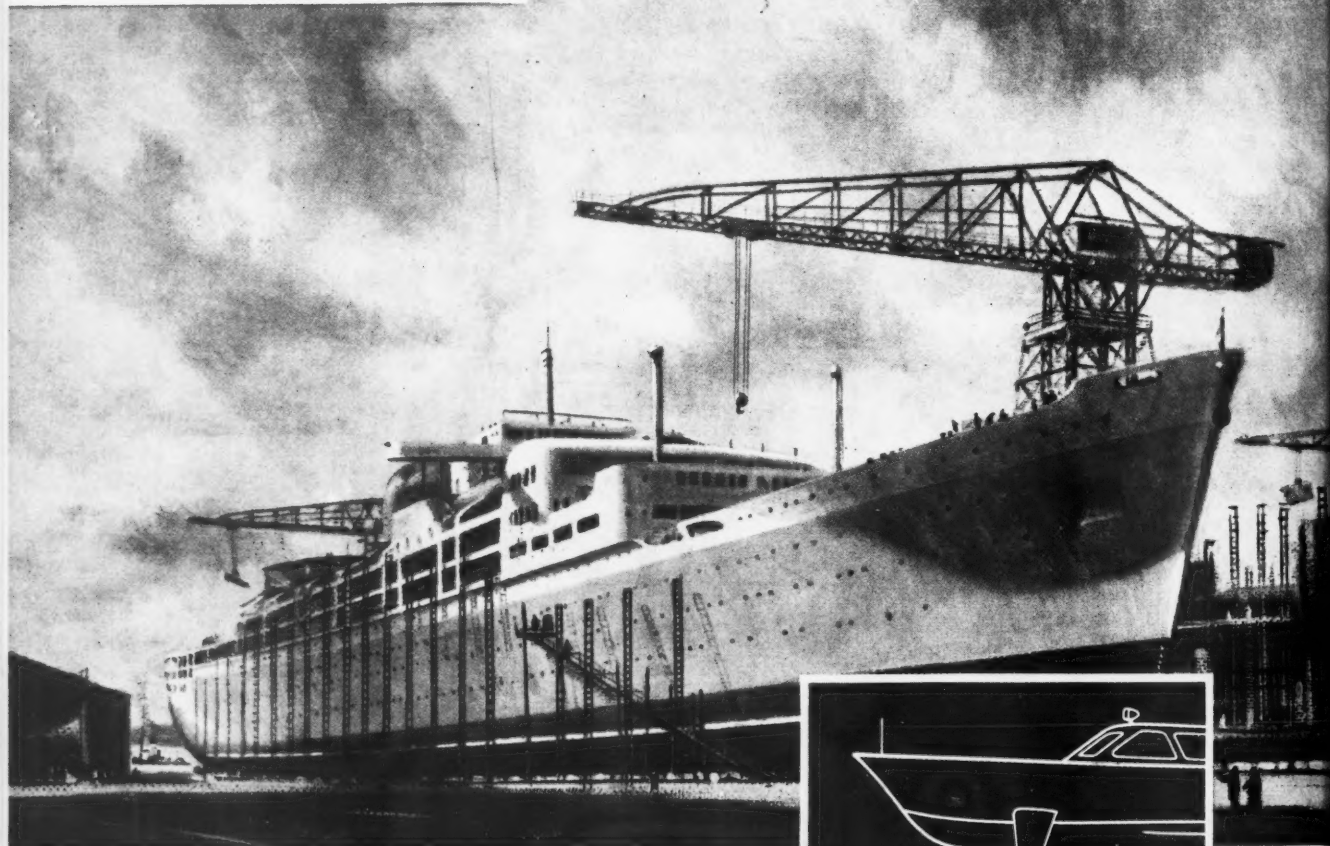
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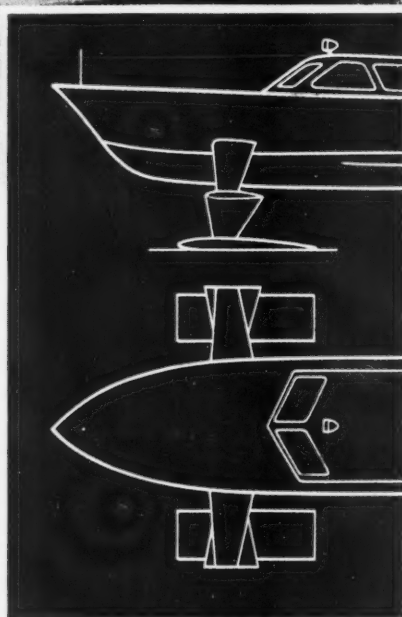
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